S. HRG. 103–406

WILL RESTRUCTURING NASA IMPROVE ITS PERFORMANCE?

Y 4. C 73/7: S. HRG. 103-406

Will Restructuring NASA Improve its...

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGYAND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED THIRD CONGRESS

FIRST SESSION

NOVEMBER 16, 1993

Printed for the use of the Committee on Commerce, Science, and Transportation

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WILL RESTRUCTURING NASA IMPROVE ITS PERFORMANCE?

TUESDAY, NOVEMBER 16, 1993

U.S. SENATE,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY,
AND SPACE OF THE COMMITTEE ON
COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:40 p.m, in room SR–253 of the Russell Senate Office Building, Hon. Charles S. Robb, presiding.

Staff members assigned to this hearing: Elizabeth Inadomi, staff counsel; and Louis C. Whitsett, minority staff counsel.

OPENING STATEMENT OF SENATOR ROBB

Senator ROBB. The subcommittee will come to order. The chairman of the subcommittee, Senator Rockefeller, has been delayed. He is chairing a hearing of the Veterans Affairs Committee.

If you were watching on a television monitor, you would see that he is still fulfilling that duty. I agreed to go ahead and start the hearing so that we could put all the testimony on the record, and would not otherwise unduly delay all of those of you who have been kind enough to come.

This hearing is a continuation of the examination of the role of NASA in the postcold war era.

Mr. Chairman, your comments, please.

OPENING STATEMENT OF SENATOR HOLLINGS

The CHAIRMAN. In today's hearing, the committee continues to examine the role of NASA in the postcold war era. In the recent committee hearing on NASA's relevance to the economy, NASA's contributions to U.S. competitiveness were evaluated. Today, we will examine whether restructuring NASA can improve NASA's performance to ensure that its contributions can be realized.

Over the years, we have witnessed NASA's achievement of monumental technological accomplishments which have taken us beyond our everyday lives. However, in recent years, we also have witnessed many flawed or failed NASA missions. The spate of spacecraft failures and botched missions, combined with persistent problems in managing programs, is cause for great concern about the future of the NASA program.

The growing number of NASA's technological and managerial problems lead the American public to question the substantial investments made every year in NASA. With a $300 billion Federal

deficit, NASA can no longer ride on the coattails of past successes. To gain the confidence of the public and full backing of Congress, NASA must demonstrate that its mission reflects national priorities and that efforts to restructure the agency will lead to improved performance. NASA's future depends on its ability to respond to these challenges.

Thank you, Mr. Chairman.

Senator ROBB. Thank you, Mr. Chairman. We look into the continuing examination of the role of NASA in the postcold war era. We have three distinguished guests, and will begin with Dan Goldin, who is, of course, the Administrator of NASA. Were you prepared to lead off?

Mr. GOLDIN. I will do that.

Senator ROBB. Mr. Goldin, OK. I am just taking the order listed on the agenda at this particular point. We will reserve the chairman's opening statement until he is able to arrive, and I expect that will be shortly. And then, Mr. Augustine and Dr. Frosch, we will be happy to hear from you.

But, Mr. Goldin, as the Administrator of the National Aeronautics and Space Administration we have heard from you on a number of occasions. We would be pleased to hear from you this afternoon.

STATEMENT OF HON. DANIEL GOLDIN, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. GOLDIN. Thank you, Senator Robb.

I am very pleased to be here today as you consider some of the fundamental questions about America's exploration of air and space. I thought a great deal about today's hearing and about the issues we will touch on today. I have prepared a written statement, that is quite lengthy, that deals with some of the basic concerns I have for NASA in our future. With your permission, I would like to submit that for the record and begin with a brief opening statement.

Senator ROBB. Without objection, the entire statement will be included in the record. We would be pleased to hear your abbreviated version.

Mr. GOLDIN. Thank you, sir.

We are here today to talk about a governmental organization that is at a crossroads. We at NASA deal with great questions of our time. We deal with who we are and where we have come from and where we are going. And at the most basic level, we are here to discuss today why does this country have a NASA, what do we want it to accomplish, and what can we do as stewards of the public trust to make it thrive and grow in the years ahead? What can we do to make NASA successful?

And that is where we have to begin to define our terms. What is success? What, indeed, is failure in an enterprise that does almost all its work at the cutting edge, at the very frontiers—at the very threshold of the frontiers of the future?

Let us remember that NASA is an agency that performs bold, notable, and imaginative tasks in air and space. We push back the boundaries of mystery and expand humanity's storehouse of knowledge. NASA's mission is to help us understand our place in the uni-

verse as human beings. We work to propel our society into a better future, and we work to make lives better and our children's lives brighter.

What other agency in the U.S. Government operates in a realm that encompasses everything from the fires that burn at the heart of a distant sun to the glow of lights in the eye of a young child? The answer is no other agency does that.

And now, Mr. Chairman, now more than ever, we should value the return that NASA brings to a relatively small investment. Now that the cold war is over, we are a nation that is looking for a new compelling identity. We used to be the champions of freedom, the light of the world. Now we search for meaning and purpose and direction in a time that is punctuated with dramatic change. Our society is so bound up with the present that we seldom take time to consider the future.

But NASA is about the future. That is what we do. We go to the cutting edge. We define success and failure in a very public way. A NASA mission takes off in full view of the world and it operates in full view of the world, and at the same time our missions take place amidst harsh cosmic backdrop.

Apollo could not fly halfway to the Moon, Magellan could not just fly halfway to Venus, the Voyagers could not just fly halfway across our solar system. The absolute technical requirements we face drive our planning and technology, and the absolutely public nature of these events drive our sense of ourselves. It is there for all to see. That is why NASA's good times and bad times are very magnified. That is why this relatively small agency that spends less than 1 percent of the Federal budget is the subject of so many column inches in the newspapers and on the TV's.

But it is important to realize that when we undertake these difficult tasks, we are also pushing America forward. We would go nowhere if we simply ambled into the lab and puttered around. Without our demanding requirements, technology does not advance. It does not reach for the next level of achievement, it does not make breakthroughs, it does not change the world. And NASA, I would like to remind you, has a 35-year history of technological contribution, and many of those contributions have literally changed the face of our society.

In this tough business, you have to have objectives. You have to reach beyond your grasp to produce success and progress. You cannot go by the yard; you have to go all the way. And so that is what makes NASA different from any other agency in the Government. We have a quest to collect meaningful science and to develop useful technology, and that mission dominates what we do. We exist to explore this planet from air and space. We exist to understand the environment of our home planet to learn more about how humans impact our ecosystem, and to give policymakers the answer they need to protect the Earth's bounty for future generations.

We exist to study the universe and our own solar system and our place in it. We exist to send humans into space, to develop new techniques and new laboratories for scientific research. We exist to solve the fundamental problems of flying in air and space. We exist to tackle tough problems. And when we stumble and fall, we exist

to pick ourselves up, dust ourselves off, and carry the Nation's hopes forward.

We exist to better understand this miracle of creation that we call the human body. Our body is like a spacecraft. It has pressures and fluids and temperatures all being maintained in delicate equilibrium; so do the machines we fly, and the connection is more than poetic. We learn from studying healthy people in an abnormal environment how to help sick people here on Earth.

We exist to fly aircraft higher and faster and safer and cleaner and more economically, and in the process we make America more competitive in the global marketplace. To do this we are dominated by four objectives that drive and guide us. First, we have to be relevant to America. Our goal is to make our work count for the people of this country. We helped usher in the digital revolution, we helped to create the medical-technological revolution, and now we intend to be on the cutting edge of the trends and technologies that are sweeping us into the future.

But relevance is more than new technologies; it is also food for the soul. It is intellectual nourishment, it is taking leaps of faith and large and small steps of understanding. Who among us, whether on a windswept mountaintop or a sandy beach or around a campfire in the forest, has not looked up to the stars to wonder? Who among us, in the long line of human generations, has not thought about our place in the cosmos? And what other organization within this Government does as much, year after year, to help answer those questions? That, Mr. Chairman, is true relevance.

Second, we take responsibility seriously. Both as individuals and as a group, we are responsible for the public's trust in us. We are responsible for some of the most exotic technology that now exists on Planet Earth, and in some cases we were responsible for people's lives. We are responsible for the dream of exploration and the discovery of new frontiers.

Third, we believe in teamwork. Just look at the team that has come together to mount the upcoming mission to repair the Hubble Space Telescope. All over this agency, from Greenbelt to Huntsville to Houston, from Pasadena to Cape Canaveral, our very best and brightest have come together on one of the most demanding missions we have ever flown. They have worked and worked and worked. They have taken individual responsibility for this mission and they have come together as a team.

And I am proud of them, NASA is proud of them, and I think America should be proud of them. No other nation on this Earth could even begin to think about pulling off such a job. And we are not only—and we not only can think about it, we can do it, and that is because of the team we have built in this country.

Finally, we believe in taking risks. This flight to repair the Hubble is a risk. Coming on the heels of some highly publicized setbacks in recent months, there are many who do not believe we can pull it off. There are many who would howl with indignation if we have problems. Perhaps some would howl with glee.

But you cannot have it both ways. You cannot be bold, you cannot go the cutting edge if you are worried about taking risks. If we allow risk aversion to overwhelm us, then we are done as a useful and productive agency for the public good. We are not afraid to

mount this mission to repair Hubble. We will not be swayed by the fear of setback. And if we fail, if we have problems, we will dust ourselves off and do it again.

Mr. Chairman, I would like to close with this thought. NASA is a litmus test for our society. We are at the boundaries and the vanguard asking questions, learning new things, and lighting the ways for a better future.

And I want to tell you about a man from another country who wrote us recently. His name is Richard Mott. He said:

I am not connected with the aerospace industry, but I cannot remember a time when space did not fascinate me. To have been alive when the space age dawned and to be able to witness it as it progresses is a great privilege, and it seems wholly natural that America should be the best and No. 1 in this field.

My interest in NASA is not mindless idolatry, but a logical steady reverence for an organization charged with the mission of taking humankind ever upward in achievement and aspiration. If the desire to do this ever fades, not only will it signal the gradual decline of a great nation, it will be symptomatic of a people who have defeated one enemy, the threat from the East, only to succumb to an invisible and far more dangerous adversary, apathy.

When we stop caring, we stop doing, and when that happens we start dying. Thank you very much, Mr. Chairman.

[The prepared statement of Mr. Goldin follows:]

PREPARED STATEMENT OF DANIEL S. GOLDIN

I am very pleased to appear today as you consider where NASA is going, and what the future holds for the exploration of air and space. I welcome this discussion, and I look forward to answering your questions.

I believe the future of this program can be bright. I believe NASA is well postured to continue operating at the cutting edge of science and technology. I believe we can continue to make fundamental contributions to the store of human knowledge. We can continue to specialize in the pursuit of high technology. We can continue to seek, to explore, to find.

Our purpose today, if I may, is to consider how change at NASA is progressing, and whether that change may be expected to result in improved performance in the future. I would submit that we are already seeing very positive signs of change at NASA. I believe we are already rewriting the pages of our future.

We have faced up to a difficult financial outlook, in uncertain times, and we are making hard decisions in the interests of that future. We are cutting bureaucracy, we have trimmed low value-added work from our agenda, we have reduced the costs of operations. We have already achieved substantial savings through this effort, and I am proud of the NASA team for how responsive they have been and for how hard they have worked.

I think we have a better program as a result of this exercise. We have prioritized, We have challenged, we have changed. The women and men of NASA have undertaken a deep self-examination. They are working hard to eliminate wasteful practices. We are a leaner and meaner agency. As a result, we incorporated about $16 billion in savings from the previous plan into our FY 1994 budget request. We have stepped up to the challenge laid before us by President Clinton to reduce costs. To implement the recommendations of Vice President Gore's National Performance Review, we are cutting an additional $2 billion. And we are pursuing still other savings and efficiencies in our planning for next year.

So I believe change is already making itself felt across the length and breadth of NASA. We are moving the culture of this proud agency toward a triad of values, based on relevance, responsibility and teamwork. We have shown that we can accept tough challenges and meet them. We have done it with our budget. We have done it with the reordering of priorities within that budget. And we have done it with the Space Station, the Space Shuttle and our other science and technology programs.

Consider some of the achievements our team has produced in the last 18 months:

- The Space Shuttle continues to fly, and fly safely, at a reduced cost to the nation. Overall, between 1991 and 1998, we will have cut the cost of flying the Space Shuttle by over 20 percent. We are looking for further efficiencies, for better and cheaper ways of doing business. But safety remains our number one priority.

• And performance and achievement remain the hallmark of the Space Shuttle program. Witness the flight of Columbia, which concluded November 1 after a voyage of more than 14 days and almost 6 million miles in space. It was the longest flight so far in the Shuttle era, and the important medical science research we accomplished provides just a glimpse of what we'll be able to do in the Space Station era.

• Under the leadership of President Clinton, we are now ready to move into that new era. With the President's guidance and support, we are dramatically reshaping the Space Station program. Over the period from Fiscal 1994 to 1998, we reduced funding requirements by $6 billion. We reduced management overhead on the station program, eliminated layers of bureaucracy, and cut the space station program staff from 1,600 to 300. We have reduced life cycle funding requirements. And in the end, I believe we have a better, more achievable plan for putting a research laboratory in low Earth orbit by the end of the decade.

• We have reached out to other nations, and reacted to the historic trends of our time. We have reached out to Russia, and are working to forge a new and dramatic partnership in space. From cooperative flights aboard the Shuttle and the Mir space station to the possibility of a joint program to develop the international space station facility, we are on the verge of a new and exciting era in the history of the Space Age.

• At the same time, we have a new budget for Fiscal Year 1994 that contains four new spacecraft starts—for the Tech SATs, the Near Earth Asteroid Rendezvous mission, the MESUR/Pathfinder probe to Mars and Gravity Probe-B, which will perform fundamental physics research while also returning exciting new technology to the private sector. In addition, we are examining the possibilities for a follow-on to Mars Observer. These are the kind of smaller, faster, better and cheaper programs upon which NASA will base much of its future. They will require tens to hundreds of millions of dollars, not billions. Most will take three years or less, not a decade or more. And they will incorporate leapfrog technology that can spinoff into the private sector.

• We have made great strides toward bringing our programs into balance. There is a balance between big science and small science. There is a better balance between human and robotic spaceflight. There is a better balance between operations and technology. There is more money for aeronautics. There is an increased emphasis on the Mission to Planet Earth and bringing new technology into the America workplace.

• We are changing the way we do business. It is evolutionary, but it is changing. We are dramatically changing our contracting emphasis. Instead of micro-managing the contractors, we are beginning to tell them what we want and then getting out of their way. We are reducing the number of change orders, stressing contractor metrics and contracting for data, not hardware. We are paying for performance, not just the promise of performance.

• We are reforming and revitalizing our management structure. We have instituted a Program Management Council that conducts what we call yellow light reviews when programs exceed budget by 15 percent. We have independent cost analysis, quarterly program reviews, and major mission reviews at two years and one year prior to launch.

• I have directed the NASA team to move from a reactive technology transfer system to a proactive program that makes a real difference to the American people. Our charter is to move out boldly in the exploration of air and space. We will be bold, we will go to the cutting edge, and we will execute these programs in a few years. rather than a decade or more. By doing that, we ensure that the technological return to America will be rich indeed.

Mr. Chairman, we have made substantial changes at NASA, but there is more work ahead. We must continue to strive for an important set of goals and missions. Our priorities must continue to provide relevant returns to the American people. And I believe the Agency's priorities for the 1990s do just that.

Our foremost priority is to continue to operate our ongoing science and technology programs safely and well. That includes not only the safe operation of the Space Shuttle, but also all of the other bold scientific programs that have been funded by the people of the United States.

Our second priority is to make the international space station project a reality. Through this program, we have the opportunity to revolutionize our spacefaring skills and to return outstanding results in the fields of biological and microgravity sciences. And along the way, we might just help define an entirely new era of international peace and cooperation.

Our third goal is the extremely critical work we are doing as a part of NASA's Mission to Planet Earth. I can think of no more important contribution to the gen-

erations to come than for we, the present stewards of this planet, to do everything we can to understand, protect and nurture the environment.

The fourth of our top priorities is the revitalization of America's aeronautical base. For too long, the first "A" in NASA has been the poor cousin in funding and attention. But aeronautics is a vital American industry, and over the next few years we intend to make major investments in improving our work with that industry. We will continue to vigorously pursue several fundamental regimes of flight research, and along the way, we will help restore American aeronautics to the primacy it has enjoyed for decades.

Another of our priorities is a strong commitment to a world-class space science program. We have four new spacecraft starts in the budget for this year. We are about to mount a flight to repair the Hubble Space Telescope. We continue to solve fundamental cosmological questions with such spacecraft as the Compton Gamma Ray Observatory. We have a new Chief Scientist at NASA. In short, we continue to move ahead with our space science program, and we place it as one of our top priorities.

We are committed to making a real difference in the technology that propels this nation into the 21st Century. What binds all of these programs together is technology. Technology transfer has been a mission of NASA's since the Congress approved the Air and Space Act of 1958. But by and large, our work has relied on the gentle rules of serendipity. No longer. We are committed to an aggressive technology program that seeks to leverage America's investment in air and space, and make this program relevant to the American people. As we reach for the stars, we will pay as we go by contributing world class technology into the American economy.

In sum, Mr. Chairman. we feel good about where we are going. We are an Agency with a mission. We are a team with a plan and a dedication for the future. But I would be remiss if I did not add one major caution, and express to you my one overriding concern.

Mr. Chairman, we have cut and cut and cut the NASA program. We have been as responsive to the demands of fiscal constraint as any Agency in government. Maybe more so. And now, irrevocably, we have reached the point where the prospect of additional cuts is of grave concern to me.

When I testified before the full Committee during my confirmation hearings in March 1992, one of the key issues was NASA's budget projections. I was told they were unrealistic. There was a GAO report at the time that criticized NASA's five-year spending plan as being unrealistic. But what, I must ask, is "realistic"?

When I came before the Senate in March 1992, the President's five-year budget request for NASA was $96 billion. Then came a GAO report specifying an $82 billion plan. Last April, the President's request was for $80 billion over five years. With the latest cuts we are making in support of the reinventing government initiative, the five-year plan is now $78 billion. And we are seeking additional savings in preparing next year's budget request. All of those levels have come forth in just the last 18 months.

At the same time that I was going through the confirmation process 18 months ago, the Congressional Budget Office appeared to be representing budgetary realism when its profile assumed growth only to the extent of covering inflation. The CBO's figures were based on the $14.3 billion Congress appropriated for NASA in Fiscal year 1992. Year by year, it would have given us a budget of $14.8 billion in 1993, $15.3 billion in 1994, and $16 billion in 1995. It looked like a pretty tough forecast at the time, but I must say it looks rosy now.

Instead, in 1993 our appropriations were $14.3 billion; in 1994, $14.55 billion, about $700 million lower than the President's request of $15.3 billion. And then last Friday, I received a letter cosigned by Senator Mikulski and Congressman Stokes, the heads of our appropriations subcommittees, indicating NASA should base its planning on a budget of no more than $14 billion in 1995.

I recognize that we are in a difficult national budgetary situation. I know how it must have pained Senator Mikulski and Congressman Stokes, two strong and able champions of the space program, to forward that assessment. And I know they are aware that this is fully $2 billion less than the CBO baseline in 1992, and $1.7 billion lower than the number assumed for 1995 in the President's budget request this year. So under those numbers, if left unchecked, we will have gone from a five-year plan of $96 billion to $71 billion.

And so the fundamental question to be considered in any discussion of NASA's future is, what kind of future do we propose to invest in? How will we achieve stability in funding? How can we guarantee the American people an adequate program with these kinds of cuts? I think we have already more than fully demonstrated our commitment to making painful choices and making the tough spending cuts. But the savings we get from those actions—some of them painful, all of them politically dif-

ficult—are not going to be enough if we have budgets which don't even provide for inflation.

The message, Mr. Chairman, is that we at NASA understand the need to cut back. Our people have stood up and saluted and are making the painful cuts. But there is no more low hanging fruit. Our concerns transcend the cuts themselves. It's the continuing instability in the budget outlook, caused to a large extent by Congressional threats to terminate or otherwise significantly alter important programs, that is also of concern. I feel it is my duty as the NASA Administrator to point out the consequences of this situation.

The aerospace industry has been hurt badly by the defense reductions following the end of the Cold War. There is uncertainty out there. And I am worried that without stability, we can't expect to promote confidence, continuity, and a sense of vision in the workforce. We must stand by our people. We must stand by the merits of this program. We can't expect the same performance if we keep making cuts. It's that simple.

The American people expect a strong and dynamic space program. They want our nation to continue to invest a small amount of our national treasure in the seed corn of the future. The program we are building is one they can continue to point to with pride. But beyond the cuts we have already made, I fear we will have to sacrifice major, compelling portions of NASA's mission. And I do not believe we will serve the interests of the American people if we allow that to happen.

Taken together, Mr. Chairman, I believe this represents the sum of our priorities, our plans, and our problems. We have a bright and wonderful future in the continued exploration of air and space. We stand ready to help America shape and enjoy a bright and promising future in a new century. We continue to excite, to inspire, to lead the way to new developments and new adventures. And now, more than at any time in our history, we need to exercise the will to push on to the next horizon.

Thank you very much.

Senator ROBB. Thank you very much, Mr. Goldin.

Next on the agenda is Mr. Norm Augustine. He is not only the chairman and CEO of Martin Marietta, but he is the former chairman of the Advisory Committee on the U.S. Space Program. I might add, noting the apparent condition of his left foot, having played tennis against Mr. Augustine 15 to 20 years ago and not having fared all that well, that it looks like I ought to challenge Mr. Augustine to a tennis match rather than invite him to participate and to testify today.

But, Mr. Augustine, we would be delighted to hear from you, sir.

STATEMENT OF NORMAN R. AUGUSTINE, CHAIRMAN AND CHIEF EXECUTIVE OFFICER, MARTIN MARIETTA CORP.

Mr. AUGUSTINE. Well, thank you, Mr. Chairman. This is the first time I have come to a hearing in bandages. [Laughter.]

I do thank——

Senator ROBB. Only in Washington would the response be so quick and so universal. [Laughter.]

Mr. AUGUSTINE. Well, Mr. Chairman, I do thank you and the members of the committee for the chance to appear today. With your permission, I would like to submit a formal statement for the record and briefly summarize it.

Senator ROBB. Without objection, your entire statement will be included in the record, and we would be pleased to hear your summary.

Mr. AUGUSTINE. Thank you. And as you said, I will try to speak from the perspective of our Committee on the Future of the U.S. Space Program. Our committee did last meet in deliberative sessions in 1990. We have not met since then. In preparation for today's hearing, I did seek the input of my colleagues, and we did not have time to consolidate those inputs, but I will do my best to re-

flect their views in my remarks today. But obviously the errors will be my own.

Before I proceed, there is one point I feel compelled to emphasize. And that is that when I was first asked to chair the Committee on the Future of the U.S. Space Program, I raised two concerns. The first was that I had numerous conflicts of interest, and the second was that the company in which I am involved is deeply active in the space program. In fact, we will be involved in 31 space missions in the next 12 months, and because of that I raised a concern that there was a risk we could have some flight failures that could seriously damage my credibility as a spokesman.

And, unfortunately, both of these issues now are true, the flight failures and the conflict of interest. And I raise those simply so the committee will be aware of that today, but I will do my best to stand back and to speak as objectively as I am capable of doing.

Before one addresses how one should structure or restructure NASA, it is necessary to answer two questions that, candidly, we have not answered well in this country for decades, not since the 1960's. The first of those questions is, What do we want our space program to be? And second, Can we really afford to fully pay for this program that we want?

And, obviously, if the answer to either of those questions is unclear, or if they are incompatible, we are unlikely to have a satisfactory experience in space. Our committee, when it met, postulated a 10-percent growth of the NASA budget, which at the time in early 1990 seemed altogether plausible. Today, as we know, the actual case is closer to zero real growth.

This necessitates at least some vernier corrections in the recommendations that our committee had made, and I would like to address some of those now. We said that we thought there should be a balanced space program, and we still feel that way. But some areas deserve special prioritization when funds are as limited as they are today.

We continue to believe that the science program deserves first priority, since it is the science program that underpins essentially all we do in technology. That is where our basic knowledge is derived. Next to the science program, certainly the Mission to Planet Earth deserves a great deal of attention. It impacts the life of those of us here on the Earth directly, and for that reason we think it deserves priority. And that impact can obviously be in areas ranging from helping to improve the environment to forecasting crops or finding natural resources, weather forecasting or a host of other missions.

The third mission to which we spoke was the Mission from Planet Earth. And if you were to read our report, we worded that recommendation very carefully, because we had anticipated we might find ourselves in exactly the position we are in today. We said that that mission should be conducted on a go-as-you-pay basis. Now, it had not been our thought that we would be able to afford to pay so little. We stand by the belief that that is an important mission, but clearly it has moved well distant into the future.

Nonetheless, the first step in the Mission from the Planet Earth, the first big step, was the space station. And it was our view that the space station is justified really only on the basis of the data it

gathers on long duration human exposure to space. But we think that was a good justification, although we recommended a redesign of the space station to make it smaller, less costly, and less risky. And we are encouraged that that has been happening, although perhaps not as elegantly as we might have hoped. But it is happening. Certainly, this Mission from Planet Earth should contain a part that includes robotic exploration, and that we can continue with, I would assume, in the near term.

The fourth element of the space program we described is the technology base. That is the part of the program that underpins the space program as a whole. It is the seed corn for the major programs and projects of the future. Fortunately, it is not a very costly element, but it is also a very unglamorous element. And so it deserves particular care.

Then finally the subject of access to space was an issue we raised. We proposed that the shuttle not be used for space "trucking," but rather only for missions where a human presence in situ is of value to carrying out a mission. We still feel that way and, in fact, the Hubble repair mission that Mr. Goldin referred to is a classic example of the correct way to use a space shuttle, in our view.

We argued for beginning a new unmanned but man-ratable expendable launch vehicle. We still believe that need is present, but we also recognize the reality of the budget. And we had a great concern, and we still do, that NASA's platter may be very full. And because of that, we suspect that it is necessary to defer the new launch vehicle into the future, and that being the case we would propose, in the near term, to put some money into basic research seeking true breakthroughs in cost of launch vehicles: true breakthroughs, not 20-percent improvements.

And second, we think the time has come to improve the reliability of the existing fleet of launch vehicles. To those who have been involved in those vehicles for many years, I think the surprise is not that they are as unreliable as they are, but the surprise is that they are as reliable as they are, for they have many, many single-point failure modes designed into those systems.

Well that then, Mr. Chairman and members of the committee, would be my effort to summarize the views of the Committee on the Future of the U.S. Space Program, as seen from the perspective of 3 years later.

Thank you.

[The prepared statement of Mr. Augustine follows:]

PREPARED STATEMENT OF NORMAN R. AUGUSTINE

Mr. Chairman and members of the committee, I am grateful for the opportunity to appear before you to share some views on America's civil space program, a pursuit which I consider to be of considerable importance., You have asked that I view today's space activity from the perspective of the work performed by the Advisory Committee on the Future of the U.S. Space Program, which it was my privilege to chair. It is appropriate to note that at the time I was asked to do so I raised two concerns regarding my involvement with any effort having such potential significance for our Nation's space pursuits and the impact they in turn can have on economic competitiveness, the advance of technology, the creation of new knowledge, and America's image at home and abroad. The first of these concerns was that I had numerous conflicts of interest relating to ongoing space matters. The second was that the possibility existed, given my service with a corporation heavily involved in space (some 31 flight "events" in the 12 months now ahead of us), and

given the nature of space activity, that the firm I lead might at any time find itself responsible for a series of space failures which could considerably discredit my views. Unfortunately, both of these concerns are a reality today.

Having offered this caveat, I will nonetheless try this morning, as I did at the time our commission was deliberating, to set personal interests aside and, to the best of my ability, seek to answer the questions you have posed.

As you know, the Advisory Committee on the Future of the U.S. Space Program has not met in deliberative sessions since 1990, and we are greatly saddened that one of our members is now deceased. I did seek this past week to inquire of our remaining members their views on the questions you have raised. Due to time limitations, it was not possible to conduct a dialog or resolve conflicting perspectives; hence, what I will present today is my own assessment of the consensus of our committee. I would note that the findings of our original effort in 1990 did in fact represent the unanimous view of our members.

A great deal has changed since our commission first met, now more than 3 years ago. Perhaps most significant is that, in part due to the serious budget deficits our Government continues to face, civil space activities no longer seem to enjoy the broad support they embraced in earlier periods. You will recall that our committee, based on discussions with virtually every decisionmaker then responsible for the Nation's civil space program, posited a budget which would increase by some 10 percent per year as being both plausible and supportable. In actuality, the budget has declined in real terms for the last few years, and the outlook for the future appears equally austere.

Also of concern is the decline in engineering enrollment in our Nation's colleges and universities—now reflecting a reduction of nearly 20 percent in the last few years. Further, half of the doctorate degrees awarded in engineering and the so-called hard sciences at America's universities now go to foreign students. Many of the Nation's best and brightest seem to opt for careers in law and business rather than engineering. This could impact America's competitiveness in this high-technology world where NASA's space efforts have traditionally served as a significant technological engine.

In addition, the epochal changes in the world geopolitical structure have suddenly shifted the space program from one driven by competition between nations to one of cooperation among nations.

These are, I believe, the three principal factors which must be addressed in reassessing the findings of the Advisory Committee on the Future of the U.S. Space Program.

At the same time, a great deal has not changed. The uncertainty then attendant to the centerpiece of NASA's space efforts, the space station, still persists. There are young engineers today who have now spent one-fourth of their professional careers designing and redesigning space stations.

Also unchanged is the fact that in spite of its many successes, the space program continues to be plagued by flight failures. When our commission was originally deliberating, attention was focused on the Challenger, the Hubble telescope, and other troubled projects. Today the focus is on Mars Observer, the NOAA I, and other failures. Worse yet, it is the firm I lead which is responsible for these failures; a fact which embarrasses—and saddens me—more than you can know.

Having considered these principal factors and other lesser ones which have changed in the intervening years since our committee first met, it is the conclusion of our group that the basic prescription we offered for the civil space program remains sound today * * * although certain adaptations are in order due to the circumstances cited.

We argued for a balanced space program * * * one involving both human and robotic activity; both science and applications; both near-term and long-term pursuits. We continue to believe that this is the proper composition of a space program pursued by a great nation such as ours. But we worded our recommendations very carefully, recognizing that funding may in fact be more limited at some time in the future than we had presumed and such a development should not be allowed to undermine the entirety of the plan we were proposing.

We were concerned that NASA had a great deal on its plate, and we are even more concerned in that regard today. We noted that two programs, space shuttle and space station, plus the infrastructure to operate NASA, consumed nearly 40 percent of its budget. This, too, remains true today. The concern we expressed over the expansive funding pressures of these three activities led us to single out one aspect of civil space activity as being preeminent among equals—namely the science program. This is the activity which produces new knowledge, builds the foundation of future education and in part underpins America's competitiveness. To NASA's credit, it has increased the relative emphasis devoted to science—but not nearly so

much as we would have preferred. We continue to believe that the science program warrants the highest priority for funding in the civil space program.

We also emphasized the Mission to Planet Earth, on the grounds that it is this set of programs which offers the next greatest likelihood of favorably impacting the quality of life for the peoples of our planet. This impact could be exerted in areas spanning from storm prediction to crop monitoring, from environmental protection to energy exploration.

We also believed that a space program for a nation with America's preeminent history in space would be a hollow one if it did not include some activity aimed at a long-term, mind-stretching goal—in our proposal, a mission to take humans to the planet Mars. But you will also recall that we worded this objective very cautiously * * * requiring that such a mission not be keyed to any particular schedule but rather be conducted on what we termed a "go as you pay basis." We identified the space station as the next step in carrying out this Mission from Planet Earth, and narrowed the space station's raison d'etre to one of providing life sciences information on the effects of long-term human exposure in space. We also recommended that the space station undergo a major downsizing to reduce complexity, to decrease the amount of assembly required in orbit, to eliminate much of the planned extravehicluar activity, as well as to reduce cost. This is now being done * * * although not nearly so surgically as we had contemplated.

Although the human exploration of Mars now appears more distant in the future than when we were deliberating (it will occur * * * the only questions are when and by whom), future exploration of the planets by robotic spacecraft was and continues to be the next appropriate step along the way. Such missions, insofar as they concern Mars, could include a sample return and even rather extensive exploration of small portions of the planet.

We further suggested that the technology underpinning the future space program as a whole had been rather badly neglected, and indeed it had. Fortunately, the cost of fixing this does not place great demands on the financial resources of NASA, but largely remains to be accomplished.

We concluded that human-piloted launch systems such as the space shuttle are not appropriate for space "trucking" but rather should be confined to uses where the in situ presence of a human being has clear value-added—and there are in fact a number of such circumstances. We raised the concern that sooner or later another shuttle will be lost—and that the Nation should get on with building a modern unmanned but man-ratable launch vehicle.

This latter recommendation appears to be the only one wherein our findings may require revision in the face of today's markedly changed fiscal environment. In this regard, we reiterate our belief that NASA's plate is overloaded and we must not be guilty of exacerbating that situation. We note that the Air Force has encountered truly precipitous reductions in its budget—including that available to support the shared development of a new launch vehicle. We observe that politically it has been impossible, during the intervening years since our study, to create a consensus to support the funding of a new launch vehicle. Finally, we reiterate that to justify the development of a new launch vehicle on a purely financial basis, any defensible discounted cashflow analysis demands true breakthroughs in cost per pound in orbit.

Given the above circumstances, it would seem that in the environment of 1994 as compared with that of 1990 the most sensible course for our space launch capability would involve three basic actions. First, use the space shuttle on a very selective basis; namely, for those missions requiring a human presence in space. Second, support those key technologies and system studies which could at some future time lead to a quantum jump, a cost-justifiable jump, to a newly developed launch capability. And, third, allocate a limited amount of funding to improve the reliability of the existing fleet of expendable launch vehicles which still have a number of single-point failure modes that can and should be eliminated. The surprising thing to many engineers is not that some of these launch vehicles have done so poorly, rather that they have done so well.

One other aspect of access to space begs addressal: the use of foreign launch vehicles to conduct America's space program. This is a critically important subject and one on which I hold a number of views. I have not, however, had the opportunity to discuss this subject in depth with my colleagues on the commission so I have deemed it inappropriate for me to comment on this topic today.

Our commission made a number of suggestions with regard to the management and structure of NASA, some of which have been implemented and some not. Among those which have been implemented were the suggestion to move the space station systems engineering organization to the Johnson Space Flight Center and to build closer ties between NOAA and NASA. Among those which have not been implemented were the proposal to create a strong independent cost-analysis group

reporting directly to the Administrator and the recommendation that a strong systems concepts/analysis group be created at headquarters. We would add today the urging that the post of Deputy Administrator be filled at the earliest possible time, and filled with a "Mr. or Ms. 'Inside'"—that is, an individual with solid operating credentials, experienced in the day-to-day challenges of follow-through management of space activities. One of the first actions of such an individual should be to laboriously and thoroughly assess the layering, efficiency, and responsiveness of NASA's infrastructure.

Since we addressed the subject of international space cooperation only briefly in our initial report, we would like to add a few summary observations here. International projects offer many significant advantages, among which are the sharing of costs, the sharing of technology including hardware, building common political interests, and, candidly, some would add making it difficult to back out of a project once begun. On the other side of the ledger, international programs are far more complex to manage, governments and their priorities change, there is technology leakage that can impact the commercial sphere, and anticipated net costsaving are seldom realized.

Nonetheless, we believe that in balance international cooperation in space is clearly warranted—we would merely offer to NASA the cautions that such cooperation is most easily implemented on small, short-term projects such as science projects; that managing "contractors" abroad will not bear any resemblance to the sort of management to which NASA is accustomed, and that particular care need to be exercised when dealing with nonmarket economies that America's own space industrial base, already badly weakened by cutbacks in defense, not be reduced to an ineffectual condition. Finally, we would note in passing that space programs have tended to evoke a somewhat nationalistic pride on the part of the public. Any activity that might be viewed, correctly or incorrectly, as merely a "subcontracted" space program to a foreign nation may not be able to sustain broad public support.

In summary, what is needed for America's space program is a clearly stated and broadly embraced vision, whether it be the one our committee has offered or any of a number of other alternatives * * * and then to STAY THE COURSE. We cannot as a nation afford, economically or imagewise, an overreaching space program blurred by uncertainty, backed by hesitation, and underpinned by redirection. Such a program would be an injustice to the American public which has for four decades supported the civil space program and would be a disservice to the many talented and dedicated people at NASA who devoted their professional lives to carrying out whatever program has in fact been defined. What is needed in America's space effort even more than money is stability. And in terms of money, what is needed is a program which "matches the money"—that is, a program where there is not continued pressure to cut corners.

Aside from thanking my colleagues on our commission for their understanding and their helpful inputs this past week to this statement—and expressing the hope that after reading this they may still believe that I was serving on the same committee as they—I would conclude with the words President Kennedy used when he spoke of America's space program: "We do these things," he said, "not because they are easy but because they are hard." This coming July will mark the 25th anniversary of the landing of the first humans on the Moon. What better time for President Clinton to articulate a strong vision for the next 25 years—and for all of us then to get behind the President to assure the success of America's space pursuits in the years ahead?

Thank you, Mr. Chairman and members of your committee, for permitting me this rather lengthy statement. I would be pleased to answer your questions.

Senator ROBB. Thank you very much, Mr. Augustine. For our third panelist, we are delighted to have with us today is here both in a current capacity as well as an alumni capacity as a former administrator of NASA back in the 1970 to 1981 timeframe. He currently is senior research fellow at Harvard's J.F.K. School of Government. He served in the interim as vice president of General Motors Corp. for research.

Dr. Frosch, we are very pleased to have you here and we would be pleased to hear from you.

STATEMENT OF ROBERT FROSCH, SENIOR RESEARCH FELLOW, CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS, JOHN F. KENNEDY SCHOOL OF GOVERNMENT

Dr. FROSCH. Thank you, Mr. Chairman. I as well have a fuller statement that I would like to submit for the record.

Senator ROBB. Without objection the entire statement will be included in the record, and we would be pleased to hear whatever summary of that statement you would like to make.

Dr. FROSCH. Thank you, Mr. Chairman. I am honored to testify at this hearing on the question, will restructuring NASA improve its performance? Let me start by giving my answer to the question: not necessarily.

I have to state that, of course, I have not recently been involved in affairs at NASA, so I cannot speak from current knowledge. What I can do best is tell you something about what I believe to be the conditions for a healthy agency and a healthy program.

The first thing that NASA needs now, and I entirely agree with Norm Augustine, is a clear sense of mission or missions. It's not just what NASA thinks the mission to be, we need some kind of consensus of the Congress, and the Executive, and the agency, so that there can be a decision as to what its task is for the next few years. The task must be fitted to a sense of what it will cost so that it can be stable for a reasonable period of time.

It has to be noted that no matter what the mission mix is, it takes a long time to carry out the kinds of projects that are involved in this business, and therefore there must be some reasonable stability of purpose and of function.

It is the kind of program that requires something which has increasingly been removed from the practice of work in the Government. Namely, it requires open collegial discussion inside the agency, and between the agency and its agents; namely its contractors and its internal Government cooperators. This has to be a discussion which is open and free. It has to be a discussion that continues during the development of projects, and it has to involve changing projects in the course of the development to accommodate to the realities of development and of new ideas.

I have to say that increasingly over the years the realities of the procurement system, of the auditing system, and of the personnel system have tended to make what is required for healthy programs more and more difficult, if not impossible.

Reliability, cost, schedule, and performance control are achieved by a passion for technical excellence, for standardization where that is a good idea, and for continual balancing between innovation and change. This requires a mixture of continuity of judgment with invention, the change and balancing of possibilities through open discussion. This dialog, as I have noted, has to continue during the development of the project.

Now, it is clear that such an open process can from time to time be subverted and can in fact have waste and fraud in it. But the tragedy has been that the occasional difficulty has been converted—and I am sorry, Mr. Chairman, I have to say it this way—has been converted, frequently at the urging of the Congress and with the cooperation of the bureaucracy, into a system which is self-defeating because it strangles precisely those processes of open

discussion and interchange that are necessary for a healthy system.

Senator ROBB. Dr. Frosch, you are not the very first that might suggest that there is room for improvement in congressional procedures, but please continue.

Dr. FROSCH. What has happened, of course, is that we have tended to substitute for an open system a system of bureaucratic trivia, a procurement system which prevents discussion by insisting upon "arm's length dealings," with a professional core of people who have no particular technical competence sitting in the middle as a procurement executive, and an auditing system that concentrates entirely on the unimportant in an attempt to find out the trivial so that it can be magnified into something which is interesting.

This is not to say that oversight is not a good idea. It is to say that oversight has to involve technical competence and a concentration on the things which are important in order to carry out a project, not upon finding fault with things that can otherwise be corrected, and putting patches upon patches upon patches on a system.

We now have a system in which watchers watch watchers, who watch watchers, who watch watchers watch. This would be useful if there was any evidence that it had prevented any difficulties of waste, fraud, and abuse, but there is no evidence that it has done that. In fact, I think a reasonable case can be made that it provides the underbrush in which some very questionable things have gone on. It does succeed in preventing precisely the open processes that are required in order to have a healthy system.

That is, I think, my central message. We need to return to a period in which the system is more open, the system is simpler, and the technical people are much more in charge of doing the technical tasks once there has been a political, governmental, and public agreement on what the task is. Then they are to be judged on whether the task is carried out, not to be judged on whether there were minor difficulties around the edges which, in fact, should be found and dealt with, but not dealt with in such a way as to prevent the success of the system.

I comment in my submission that we have grown so concerned that the kitchen be kept completely clean that the army of cleaners is preventing the cooks from preparing the meal. So, we have a nice empty kitchen, but nothing on the menu. We are not preventing bad behavior, and we are not getting the product we are paying for either.

It seems to me that at a time in which we are talking about reinventing Government, perhaps we ought to think seriously about reinventing it in a direction which will allow the accomplishment of bold, and difficult, and risky things, understanding that even if they are accomplished superbly, if they are as risky as we want them to be, as Dan Goldin says, there will be failures. And the failures are not to be an occasion for the destruction of the rest of the program, but an occasion for learning and knowing how to go on in a better way.

Mr. Chairman, that is the key summary of what I wanted to say to the committee.

[The prepared statement of Dr. Frosch follows:]

PREPARED STATEMENT OF DR. ROBERT A. FROSCH

I am honored to have been asked to testify before you at this hearing on the question: Will restructuring NASA improve its performance?

My answer to the question is simple: not necessarily. Unless there is a clear grasp of the problems to be solved by a restructuring, and an understanding of the essential organizational and professional practices that lead to better performance, moving organizational boxes around will generally be fruitless.

I have not been involved directly in the events of recent years at NASA; my understanding of them is based only upon occasional contact with NASA people, what I read and hear in the public press and media, and what I can deduce by extrapolation from the period when I was Administrator, now more than a dozen years ago. Therefore I cannot comment in detail upon recent events. Rather, I can state what I believe to be the conditions for a healthy agency and program.

The first thing that NASA needs now is a clear sense of its mission or missions, with some reasonable definition of the general program needed to carry out its various aspects. Agreement on this must be shared well enough by both the executive and the Congress so that there is reasonably consistent and continuing support for carrying them out. It is possible that redefinition of the missions of the agency, and of the general allocation of its resources to them will point towards a restructuring, but a restructuring discussion before some kind of consensus is reached on the mission package is likely to be a mistake.

I do not believe that such a consensus is now in place. The possible missions have been clear all along, and I will not restate them here, nor will I give my own views on the choices among them, since this hearing has not been called to discuss that subject, and I to not wish to lead it into a digression. Should you wish to hear my views on that subject at another time, I will be happy to give them.

Nevertheless, whatever the mission set decided upon turns out to be, it is clear that without a reasonably stable mission assignment, tailored so that the elements of the missions chosen can be carried out within the resources made available, the agency will continue to be buffeted by internal and external arguments about what it is supposed to do. The attempt to accommodate to continually changing voices, whether from inside the agency or outside, will continue to distract it from carrying out any of its missions superbly. It is sensible to carry out assignments as efficiently and frugally as makes sense given the nature of the assignment, but it is not sensible to agree to, or to be forced to agree, to do projects much more cheaply than anyone really believes is possible.

It takes years, sometimes decades, to carry out the long and difficult projects that are characteristic of both space and aeronautical programs. There must be some consistent dedication of resources and effort to such programs, or the vagaries of continual policy change will ensure that there will be trouble. No organization can be expected to reprioritize, rebudget and restructure endlessly without losing its ability to perform. If the mission definition or redefinition requires restructuring it would make sense to do so, but not as a prelude to doing so again every time there is a problem with the program, or even a sequence of problems with projects.

Working on these long and difficult technical programs requires open, collegial discussions and interchange between technical and professional government people who are competent to conceive and plan such programs, and guide them over a long period, and those who are responsible, either in the government or by contract, for doing the specific work necessary to deliver the programs. The essence of success lies in open communications internally and externally among those involved.

Reliability and cost, schedule and performance control are achieved by an understanding of the purpose of the program and project, passion for technical excellence, learning and improvement by experience, standardization of what gains nothing from being new, and a continual balancing between innovation and change, and continuity in the development of new work. This all requires a continuity of judgment with invention and change, and continual balancing of possibilities through open discussion and interchange of a diversity of ideas. It requires, in short, an open technical and program community, blending the best talents of the government people who represent the requirements for the work to be done, and the government and contract people responsible for carrying out the work.

The dialogue among these people should continue during project development so that the best solutions to the real intention of the project may be developed by considering the objectives and possible solutions together. This requires adjusting changes in requirements to the technical reality of the project development, and being prepared to adopt and allow new ideas about technical solutions. All this is part of the search for better on time, on cost and on performance delivery of project results. The idea that this can all be predicted in advance, poured into rigid and

never-to-be-changed specifications, with the details to be worked out at "arm's length" is simply wrong, and is itself a delusion responsible for some of the troubles.

Clearly the open process can be subverted and turned into waste and fraud, but the current system appears to be such a complete failure, in all agencies, that it seems worthwhile to return to a system based upon the plain facts about how good projects work, and then to police them with trust and vigilance. While there are always some crooks around, there are generally many more honest, trustworthy and competent people around, in both government and industry. If we want successful projects, we need to depend on trustworthiness more than we do.

We cannot continually substitute bureaucratic trivia ("mickey mouse") for real technical work, and expect anything useful and productive to result. It is easy to blame the "bureaucrats" in NASA for the nonsense, but they have been driven to their behavior by forces largely outside the Agency, in the executive and the Congress. Over the years, increasingly bizarre processes and ever more complicated formal systems have been invented as attempts to solve real and fancied program problems, until by now, the processes have merely become an inadequate substitute for doing anything properly.

Systems that assume that discussions between colleagues inside the agency, or between the responsible government people and the responsible contractors should be held "at arm's length", with technically ignorant legal and procurement officers in the middle, simply destroy the possibility of the working relationships that are necessary for success. Personnel systems that assume that the working experience that produces the knowledge necessary to be a professional government person amounts merely to 'conflict of interest' are likely to prevent the government from recruiting the best people for such jobs. Systems that block these technical people from resuming sensible careers after they leave the government don't help to recruit and retain the best people.

I know of no evidence that the formalistic systems have had much, if any, effect on preventing improper behavior, (although that is generally the excuse for their establishment), but they certainly do result in chronic government performance that is less excellent than it could be. We lose much more by such systems than we gain! I would be more sympathetic with such systems if I had ever seen a shred of evidence that they prevent any waste, fraud or abuse, or, indeed, served any purpose except to provide material for intemperate political speeches and the excuse for a bloated and unproductive paper shuffling bureaucracy.

A reasonable case can be made that the complications of the procurement system, (aside from the fact that they waste a large part of the procurement money, and interfere with the real work to be done), provide a rich underbrush for the concealment of all sorts of questionable practices. (I would guess that the federal procurement system wastes somewhere between twenty and forty per cent of all money intended for procurement. I have heard other, similar, estimates.)

The current procurement system enforces the violation of everything we think businesses have learned about the management of effective relationships among customers, the business, and its suppliers, as well as everything we know about accomplishing excellent scientific, engineering and operating work, and of doing effective technology transfer.

It is difficult even to know what is intended, allowed or proper in a procurement regulation system that has grown so complicated and contorted that it is no longer clear what it contains, whether it is even self consistent, and which requires a professional interpreter even to purchase a pencil. Some of the blame for this situation rests with the Congress, which responds to every problem with a new patch on the system, without ever forcing simplification, but some of it rests with the executive bureaucracy, which frequently overreacts in regulatory creation.

The current system of watchers watching watchers who watch watchers watch watchers is simply silly and pointless. We have grown so concerned that the kitchen be kept completely clean that the army of cleaners is preventing the cooks from preparing the meal! This makes no sense; we aren't preventing bad behavior, and we aren't getting the product we're paying for either. I would much rather take a chance on trust, get good performance and have to fight some possibility of crime, than continue with the current system, get worse performance, and still have to fight the same possibility of crime. Distrust is not a good system for getting the best performance from good people, and it doesn't deter the others much, either!

An important possible piece of a vigilance system, which the Administrator may want to use, can involve the use of third party outsiders in technical and business advisory groups to help in occasional, or regular, deep review of projects and programs. By "outsider" here I mean outsider to the project being reviewed. These "outsiders" can be NASA or contractor people from other projects or programs, or may be people from completely outside the NASA system. This is not the same as "audit-

ing", or "audit accountability", which usually involves the deep examination of bureaucratic trivia by people who do not really understand what is going on, and hence focus on nonessential issues; issues which may be worth taking care of, but which seldom tell much about what is really happening in the project.

The spirit of third party help must not be the spirit of investigation, audit or blame. It must be the spirit of the colleague who is not directly responsible or involved, but who can bring another view to the matter, perhaps critical, but in the spirit of suggesting new possibilities and alternatives. This is the provision of a kind of intellectual diversity to people who sometimes become so immersed in their immediate problems that they cannot step back enough to see what the overall problem may be. This should not be continual, but occasional, and especially invoked when the participants feel the need of another view. It should never be management or outside "oversight", but much more in the spirit of help.

Doing third party examination properly requires great restraint, and detailed discussions between the third parties and the project and program people. This function must be performed by people who respect, and are respected by, the government and contractor participants in the program. It can be a function of an internal NASA office, but this mode has the danger of degenerating into auditing and meddling. Performing this function properly takes great competence, a light hand and considerable restraint.

I have said nothing above about the balance between in-house work, done at the NASA centers, and work to be done by the contractors. Some capabilities NASA must have, particularly sufficient in-house technical capability to be able to be a "smart buyer"; to deal responsibly and competently with the contractors. Otherwise it will simply become a victim of the first untrustworthy outsider.

To have such a capability it needs some first class in-house technical operations. Depending upon the mission decisions, and any restructuring that might result, the scale of the in-house technical operations might be different than it is now, but considerable discussion would be needed to say by how much. This analysis must be initiated by the Administrator, who, I imagine, has already done so, but the Congress must be willing to make changes based on their technical and business merits. The changes must take due account of political realities, but should not overly compromise the best technical and business plan in order to take account of them.

In addition, NASA will, by default, be the owner and proprietor of R&D and test facilities for space and aeronautics which are too large or too specialized for industry reasonably to be expected to have, and which therefore will need to be national. It might be worth considering whether some of these might be international.

We should consider whether these "in-house" facilities should be civil service run, or should be contractor run. Some should continue to be civil service, although that system has developed in a direction that seems to make it less and less capable of allowing the operation of excellent technical organizations; the same political and bureaucratic tendencies that have destroyed the procurement system have been operating on its rule structure, with similar results. If the civil service system cannot be made more rational, and capable of allowing excellence to be maintained more easily, then the "in house" organizations should be run as contract operations. However, I believe that it is preferable for many of them to be government organizations because it is important that our government incorporate the sense of excellence and pride that comes from having such capable organizations.

I would like to say something additional about cost control. Given the difficult and highly developmental nature of complex projects like NASA projects, I am always amazed that anyone thinks that their costs can be precisely predicted in advance. For that reason, when I was Administrator, and in other senior government positions, I always tried to budget some reasonable contingency into projects, and into large program budgets. I was always frustrated by the OMB and congressional reasoning that budget contingencies should be dealt with by asking for more when required, not by building in realism to begin with. I could always hide a little with the help of the comptroller, but never enough to be realistic about getting the work done properly, on time and in a frugal way.

The unknowns of the program, and worse, the unknown unknowns (known in the Department of Defense as the "unk unks"; the things we didn't even know we didn't know) frequently lead to overruns. The idea that before you start a project which contains things that have never been done before you should know what the unknowns are, and what they will cost, is just silly. The idea that you shouldn't start until you do know the unknown is even sillier. The demand for this predictive certainty leads to unrealistic project budgets; "scrubbed" budgets that account for only what is understood, not what is not understood, and the latter always introduce cost problems, and frequently time problems as well. "Saving money" with unreal budgets that force programs to be stretched, and therefore more expensive, and then

complaining that they have "overrun" is a form of self delusion or dishonesty we could do very well without. Stretching programs is sometimes necessary, and even, occasionally, wise, but it should be recognized that that generally merely trades lower immediate costs for larger total costs.

In this testimony, I have tried to be realistic about what is needed in this time of reinventing government if we are to do better with space and aeronautical programs. I have tried to state the basics as I have learned them through experience, and have characterized some problems as straightforwardly as I could. I have not tried to tell you what to do, but only, in a few minutes, to lay out some principles you ought to follow in laying out the work.

I hope these comments are helpful, at least in raising some questions that I think you should ask as tests for proposals for restructuring. Unfortunately, a lot of what is implicit in my comments cannot be done by NASA alone, but must be part of the task of the executive and Congress working together to "reinvent government".

Senator ROBB. Thank you very much, Dr. Frosch. The committee stands appropriately chastened for whatever complicity it may have contributed to the dilemma you have just described, and I do thank you for a very candid and understandable critique of where we are and some of the things we need to be thinking about.

We have been joined by Senators Hutchison, Lott, and Burns in that order, and I am told that we can expect the arrival of the duly designated chairman momentarily.

Let me start, Mr. Goldin, a question for you generally. The United States of course today places more importance on international economic competition certainly than it did when NASA was established, and I would question whether or not the R&D budget ought to reflect this changed priority in terms of the current circumstances.

Mr. GOLDIN. There is a real problem in our country and it is not just in the Government. I came from 25 years in industry, and in the last 5 to 7 years I have watched the R&D investment go down as a percentage of the sales that we have as we strive to survive in the present. And it is just the reverse of what we ought to be doing as we prepare for the future.

So, R&D investment is absolutely essential. However, R&D investment should be guided by a set of principles and a vision, a map that you have in your head as to where you want to go, and without a shared vision we cannot do it.

I also believe that we are in a very competitive world, but it is a very complicated set of arrangements we have with our partners. So, to just say America is going to be isolated by itself and compete against the world is going to deprive us of a number of teaming relationships that we could have. So, I think there is another aspect that involves cooperation.

Right now if you look at the world's space programs almost every country has overlapping infrastructure. It is not necessary for some of the things we do. We could do shared infrastructure so each of us could develop the critical technologies that we want to go develop, and I believe that the time has come to really work on that. And there are possibilities not just with the space station that we are talking about now, but there are significant possibilities in planetary missions, in astrophysical missions, and in a variety of other missions, so I would put some emphasis on that.

Senator ROBB. Any specific suggestions or recommendations where that cooperation could be achieved are always useful in this process, and if there are areas particularly where NASA today

could cede some other Agency or Department the authority currently held by NASA it is always easier to start from that perspective rather than saying NASA ought to be the control agency for all functions. But I make that only as a general comment. I appreciate the comment that you make.

Mr. GOLDIN. Let me just respond by saying that in the area of aeronautics, that is a competitiveness issue for America, and that is one area that I would propose that we would really go it alone unless we could buy some specific technologies to transfer. So, I would isolate aeronautics from anything else because we are talking about 1 million American jobs in the aeronautics industry.

I think that there is a great deal of possibility in the launch arena. I know it is a very sensitive subject, but I want to say that the American launch industry lags the world. We are still using 35- to 40-year-old converted missiles, while the rest of the world has modernized its launch fleet.

And I am sensitive to the issue that Mr. Augustine brought up about the fact that we have to set priorities. But we ought to work on leapfrog technologies that Mr. Augustine talked about, but I am not quite so sure about our ability right now to maintain the kind of fleet we have.

And I give you as an example if we want to launch a mission to Pluto we will have to spend one-half billion dollars for an existing American launch vehicle, whereas if we wanted to produce that same mission to Pluto and we teamed with one of our international partners, we could take a multihundred million dollar spacecraft and put it on a $50 to $100 million launch vehicle.

So, if we stay true blue to our own industry and say we will go fly on an American launch vehicle, we will never have a mission to Pluto, and it is a self-fulfilling prophecy of no mission.

So, I think that is an area that we would have to consider. I know it is controversial, but right now we have a terrible, terrible problem that we have to deal with.

I think there is infrastructure like communications. Every nation in this world is planning a tracking and data relay satellite. That is real waste. I would hope that we could take advantage of our existing tracking and data relay satellite, and provide services to other nations so they do not have to establish a similar capability.

There are a variety of these infrastructure areas that I think that we need to take a good hard look at and decide what benefits our society and what is just planting our flag in space. We do not have the budget to do it.

Senator ROBB. I suspect that some of those who are most interested in your testimony today and are attending the hearing might have conflicting advice as to which of the areas ought to remain an U.S. exclusive and which ones ought to be shared internationally, but we do not need to get into that at this point. The general point is made.

You did talk about the success that we have had in aeronautics, and a lot of that has been due in part certainly to the close working relationship that we have had with aircraft manufacturers. I wonder with respect to the space technologies generally why have we not been able to develop a closer working relationship in some of those areas?

Mr. GOLDIN. I think we have two basic problems there. NASA has gotten so involved with our contractors we not only tell them what we want, we tell them how to do it. And that takes away a tremendous level of accountability and responsibility. I think we have good people at NASA and we have good people at the contractors, but we have gotten so involved in the details you cannot separate things out.

I had the CEO of a major company come see me, and I asked him "How do you think you are doing?" He said, "Great." And he took out this book and he showed me contract after contract where you had green lights next to each one showing that they were on schedule and on budget.

As I went through each contract I said, "Do you realize that this contract that you identify as being OK, even though everything is in scope, the contract grew by 220 percent? Are you aware that this contract grew by so many hundreds of percent?" He said, "No."

The problem that we have is this lack of accountability and responsibility. We have to separate out and then have NASA specify what we want and let the contractor determine how to do it.

The second thing we have to do is we have to set up a procurement system that is a much more forward looking procurement system. Right now the contractors are forced into a situation where they have to bid to win, and they are not incentivized to bid to perform.

We have taken a number of looks at a lot of contracts as part of our reinvention process, and we find that many contractors bid to something like 60 percent of the dollars available that NASA has because that is deemed to be the kind of winning price, and we do not have a firm set of negotiations before the award. The requirements are not fixed, so after awards the requirements grow and the contract goes up in price, and again it takes away responsibility and accountability.

So, we have got to have a procurement system that incentivizes the contractors to perform and not win, and then they have a confidence that they will be in charge of their destiny, so then they will not have to worry about other things that plague them right now.

Senator ROBB. The same difficulty, of course, is being examined in a number of contacts, particularly with respect to military procurement, and the amount of mil specs that we require and the constraints that places, and the increase in cost for some of the end items in the military area which tracks very much what you have said.

One brief followup question. Would the overattempt to say how and not just what is desired be largely a function that NASA can control within its own administrative function, or is Congress partly responsible, and would you suggest any easing up from Congress in this particular area?

Mr. GOLDIN. I would say that we at NASA, before we come to the Congress for help, ought to clean up our own act. I believe that there are a variety of things that the Congress could do, but right now the biggest problem we have is we are not taking advantage of the tremendous knowledge base that some of the companies have in commercial spacecraft fields. They have a terrific record.

We ought to be able to go to a lot of those contractors and not impose a lot of our Government regulations and say, "You put your company at risk when you take on these contracts. You are willing to do it. We ought to learn from you."

I think American industry has a lot to teach the Government. There are a lot of commercially available technologies that we could use without slapping Government paperwork on it.

So, I think that we have to ourselves do the right thing first, and then we have to get with the Congress and have the Congress deal with us the same way that we are dealing with our contractors.

We have to hold our contractors accountable and not have them worry about the style in which they interact with us, and how many points they get for being nice and saying the nice thing. We have to work with our contractors in an open fashion so the thing that counts is when that spacecraft gets launched did it work? Did it launch on schedule and was it within budget? Those ought to be the things that drive the contractors, not the style and form. And unfortunately we are a little bit too much into style and form.

The major place that the Congress could help us is to give us a stable budget. Right now, my frustration is not so much the level of the budget. We do not even have a 1-year planning cycle. We go about every 2 or 3 months literally. I have been Administrator a year and a half now, and every 3 or 4 months we are adjusting our budget for an operating plan, an action taken by the Congress. When you cannot plan you cannot perform. That is the place we need the maximum help from the Congress, stability in what we are doing.

Clearly, we want a stable level of funding at the right level, but I would vote for stability more than anything else. When I took over as Administrator, I reviewed the budget on May 6, 1992, and we had projected $106 billion for the 5 years. By a few months later, we were down to $96 billion. Our new President came in, we were down to $80 billion. We went through a reinvention process with the Vice President, we were down to $78 billion.

We began a very thorough, detailed planning process for fiscal years 1995 through 1999, and just a few weeks ago I received some guidance from the Congress that—maybe that that plan was improper, and we ought to begin planning for something on the order of $71 billion.

NASA is in chaos. We cannot develop a strategic plan, we cannot develop a vision, we cannot develop a morale among the employees that they have confidence in what we are doing, and we cannot develop a confidence that our contractors are willing to make an investment when just before Christmas we are laying off thousands of people because of the instability in our planning process.

So, what we want from the Congress is a commitment to the space program to give us a multiyear budget. Our programs last 3 and 5 and 7 years, and if we have to plan in 4-month increments, it is impossible to perform the task we are performing.

Senator ROBB. Mr. Chairman, may I thank Mr. Goldin for his testimony, since you are just arriving. I was telling the chairman exactly where we were. I had explained to both the panel and those who are assembled that you were chairing at the Veterans Affairs Committee at the same time and that ran over, and that as a con-

venience to those who are assembled that we would go ahead and begin, and I would yield the chair.

Senator ROCKEFELLER [presiding]. I apologize and thank the Senator from Virginia for proceeding.

[The prepared statement of Senator Rockefeller follows:]

PREPARED STATEMENT OF SENATOR ROCKEFELLER

Welcome to the Subcommittee's fourth hearing this year on the National Aeronautics and Space Administration. Today, we are examining NASA's role in the post-Cold War era and how to improve the Agency's performance.

We all agree that NASA needs to change. In the post-Cold War era, our national priorities have changed. Our expectations for public investments in research and development have changed. The witnesses at the Subcommittee's last hearing all stated that NASA needs to change in order to be more relevant today.

I am convinced NASA can rise to the occasion and contribute more toward the economic health of the country, but cost overruns, schedule delays, and spacecraft failures suggest there may be fundamental problems with the way NASA manages space projects. These problems have, in turn, created a image problem for NASA. I suspect that, when members of the American public are asked today what they know about NASA, they will mention the Challenger space shuttle, the Hubble space telescope, and the Mars Observer. When they read their newspapers or watch their TV news, they will more often learn that a space shuttle launch has been delayed because of equipment failures than a space shuttle was launched without a glitch.

While risks are inherent in developing and operating space projects, we need to know whether these recurring incidents are caused by isolated defects or are indicative of systemic problems. And I certainly do not mean to imply that everything NASA touches today is bad. We have all benefitted from NASA's continuing contributions to telecommunications, environmental monitoring, and astronomy. In fact, two weeks ago, I hosted a conference that highlighted NASA's contributions to telemedicine.

However, with persistent problems at NASA eclipsing its many achievements, NASA has for years relied on the old, space-proven technologies of the sixties and seventies to avoid additional spacecraft failures. As a result, NASA technology has fallen behind the state of the art in many fields. I want to explore how we can change NASA from an agency on the trailing edge of technology to one that is again on the leading edge.

Although we all agree NASA needs to change, we have not agreed on what needs changing. Partially that is because we have not agreed on what NASA's priorities should be. The Administration has stated that NASA's priorities are space station, Mission to Planet Earth, aeronautics, and new technology investments. Other Administration-identified priorities include space science and competitiveness.

While NASA's budget cannot possibly support all these priorities at appropriate funding levels, there has not been much discussion on whether those are the right ones. Neither has there been much discussion on what process will be used to reach a consensus on the priorities. We will discuss these issues today.

While the determination of NASA's priorities is of great importance to me, I am also concerned about how NASA is structured and managed to carry out its mission when those priorities are determined. Several studies have identified problems with the way NASA carries out its mission and have recommended procedures to improve NASA's performance. Many of those recommendations were implemented, NASA has been repeatedly restructured, but we are here today pondering the same issues.

In the meantime, another process of "reinventing NASA" has begun. Given the results of previous restructuring, I would like to know how this effort is different? I would like Dan Goldin to tell us how this time will be different, to state the vision and priorities on which it is based, how those priorities were determined, and what is being done to change NASA's institutional culture. These are important issues because the future of this agency depends on exchanging the priorities and methods of the past for those of tomorrow. I hope, and fully expect, our other witnesses will also comment on NASA's priorities, and its structure and methods for achieving those priorities.

I know there is a lot of anxiety at NASA. Change is often difficult for those who go through it. Budgets and personnel levels are being cut, some programs will be scaled-back, and some programs will be eliminated. But the employees at NASA are talented and hard-working team members. I know they want very much to see NASA at the leading edge, not at the trailing edge.

We are fortunate to have three witnesses who, collectively, know just about everything there is to know about NASA. I look forward to their testimony on how to improve NASA and strengthen our space program.

Senator ROCKEFELLER. Senator Hutchison, I was told you had been here a long time, and we are going right to you.

Senator HUTCHISON. First of all, Mr. Chairman, I really appreciate having the opportunity to visit here, and there were some very important points that were made, and I think the one that Mr. Goldin was making just as you came in should be reiterated 1,400 times.

As one who grieved over the loss of the SSC and who watched with horror that the space station made it by such a small margin in the House of Representatives, I think we are going to have to undertake a major educational effort of our Members of Congress. Not so much, fortunately, our Members of the Senate.

But all of us need to realize that, first of all, a commitment to science and research is one of the ways that America stays in the forefront of technology and new industries that come from those technologies, and we cannot be a major player in science and research if we are going to reinvent the wheel every year, if we are going to not only cut down, but redesign, change our thinking.

In the SSC, they found that the magnets that they had first constructed were not the right type of magnets and they had to do some changing of specifications. Well, what do you expect the first time you do something that is that massive, but to maybe accept that there are adjustments that have to be made, and I think that we have got to understand that. We have got to educate, particularly Members of Congress, that if we are going to be on the leading edge, that we are going to have to make a commitment and stick with it.

Now, obviously we are not going to do things that are stupid, or if we see that something is not feasible that we do not have the sense to back off, but I am greatly concerned about our resolve in this area, so I really want to reiterate your point, and I am sorry to make a speech to you that you have basically just made, but I think it is well worth repeating.

Let me ask you this question in a bigger picture. The suggestion in two of the rescission bills that have been put forward that are bipartisan in nature has been that we take the scientific components out of the Departments of Commerce, Energy and the EPA, and put them with NASA and the National Science Foundation for a Department of Science.

Do you think this has merit, and would it be a potential for perhaps maybe educating people better on the need for stability and the need for this ongoing effort in research that we have made a commitment to do?

Mr. GOLDIN. I think I have mixed feelings about it. First let me say that I believe that science and technology as managed by the Government ought to be mission-driven. I do not think we ought to buy science and technology by the yard, because then we do not have a measure for what we have accomplished and achieved, and send people into the laboratory and say, "Go off and invent something for me."

NASA is an agency that has a very specific mission to perform, and we ought to keep NASA focused on performing missions but demanding of NASA that it return back the investment as it goes along.

One of my concerns, therefore, would be if we say we are going to have a Department of Science, if that Department of Science could focus on mission it would be one thing, but if we just go and we buy science by the yard, I would be very, very concerned.

So, it would be that mission-driven attitude that I think is crucial, the crucial litmus test, and just stacking science together for the sake of stacking science together I am not sure will get us there, but on the other hand you could have a critical mass in terms of the ability to communicate, and for technology transfer, if you do the first thing that I said.

Senator HUTCHISON. Well, you are the head of an agency that is mission-driven, and it is single-focused, single-focused in the sense that it is space-related. Some of the other projects are within other Departments that may have many different missions, but not just those projects. Is that a plus or a minus?

I mean, obviously we cannot have a new Department for every major research project that we have. That is not feasible, and it certainly would not be cost effective, but if there were an agency that was devoted to science, that is headed by people who have at least an overall mission of research and development, and a sense of the place of research and development in our country and in our budget, would there not be some advantage to putting it there than to put a major scientific project in an agency that really has another mission that is its main mission?

Mr. GOLDIN. Again, I have not had enough time to think about it, but there are pluses and minuses to every issue. If the purpose of science is for technology transfer, that is one reason. If the purpose of—you have to ask why are you doing those scientific missions, why are you undertaking those tasks, I would have to take a look. I am not familiar with that portion of the bill. I wish I had read it in more detail.

But I would say that one ought to go take a balanced look at it, and if we could get a real value added by combining them, then I would say do it, but combining for the sake of combining does not necessarily give you the result you want.

There is a desire that I have seen in industry a number of times in the older management technique to reorganize to get efficient. What you have to do is go down to the core root values of what you are looking for and ask, "What are you trying to accomplish before you do it?"

So, just saying we are going to reorganize to get science all condensed is not enough for me. I would have to look at the mission of each of those Departments and say, "Does it make sense to take it out and put it somewhere else?

Senator HUTCHISON. Well, I am not sure that we have looked at the pros and the cons, and I do not know what my position is, but I think we should think about it, and I wish you would think about it, because I think we need to have advice from people who are experienced in mission-driven science.

I think there is more than one reason can be given for scientific research. One could be technology and new technology, and one could be the national aerospace plane, which I think is a different type of mission totally than just new technology, and so—although it is there.

So, I think we need to think this through, but I certainly think it has a lot of merit looking at it.

Is my time up?

Senator ROCKEFELLER. It will never be up as long as you have questions that are of interest to you.

Senator HUTCHISON. Let me just ask on a different subject, Mr. Augustine, there has been talk of your advisory committee being brought back together to look at the advice that you gave and how much of it has been followed, what difference it has made, and what you would prioritize again.

If that were to happen, what would be your focus now? Although the procurement I thought was covered very well by Dr. Frosch, what else would you say about we ought to be doing that would be in line with your recommendations, and what priorities would you set now?

Mr. AUGUSTINE. I believe, if our committee were to reconvene, the first thing we would need to do would be to reexamine in more detail our findings in the reality of the budget as it exists today, which is a much more constrained budget than we had imagined when we met.

We would certainly want to readdress the missions that we had proposed in more detail. The role of international cooperation deserves a great deal of attention. At the time we met, we were to some degree in an era of international competition, and today we are in more of an era of international cooperation. That clearly changes things. Finally, as I mentioned in my opening remarks, the situation in the launch vehicle area has changed drastically and deserves some very careful thought.

Senator HUTCHISON. That is my last question, but I would just like to say one thing to the point that you made on international cooperation, and that is that I think the stability of funding is going to be crucial if we are going to continue the era of international cooperation, because we cannot debate whether we are going to close down a major project every year if we are going to ask for international participation, and I agree with you, I think it is a new era.

Thank you very much.

Senator ROCKEFELLER. Senator Lott.

Senator LOTT. Thank you, Mr. Chairman. Thank you, Mr. Goldin, panel participants for your being here and for your contribution, and I want to thank Mr. Augustine for his efforts on the committee of the future of the U.S. space program.

I share a lot of the sentiment that Senator Hutchison has just expressed to you, Mr. Administrator, that if you are going to have a plan for the future, we need to be more consistent here on Capitol Hill, and I know that, and I hope that we can get the Congress to work with you and try to have some stability in keeping your budget in some sort of area where you can plan for the future without your having to go through all these different iterations and changes

every 4 months, so I do feel like a lot of the problems you have we have contributed to, if not been a principal cause.

I want to congratulate you for the job you have been doing. I think you have been doing yeoman's work under very difficult circumstances. When you see the agency basically having its budget squeezed by one-quarter over a very short period of time and then being asked at the same time to continue all the major programs that we were trying to do, that is next to impossible, so I appreciate the effort you have made.

Let me ask you, when you talked about launch vehicles, as you well know, we had the ASRM. Your three previous predecessors supported the advanced solid rocket motor engine, as did you until it was evident that the House of Representatives did not intend for that to go forward, but that presents us with another challenge now.

What is going to be there in place of the ASRM in order to continue our space program and maybe even face the challenge of this higher orbit that we have talked about? How do you intend to try to address that problem?

Mr. GOLDIN. We are going to address it a number of ways. First, we have got to get stability into the program. I keep coming back to this same basic theme. You know, there are human beings involved in this that are getting ripped up and moved around, so the first thing we have to do is take care of the human beings involved to the best of our ability.

Next, we have to take a look at three basic areas. First, we are going to lighten the weight of the existing shuttle. When we go up to 51.6 degrees we lose about 12,000 pounds. We lose that weight because it takes more energy to go to a higher inclination, and so the first step is, we are going to go develop an aluminum lithium tank. This saves us about 8,000 pounds.

The second thing we are going to do is, on some missions where we do need the extra throw weight we will discard the solid rocket motors. These—the casings, after the flight, are used about 18 times, so we will try and take the older casings and discard them, and with some minor design modifications to that, we could pick up about 3,000 pounds.

Finally, we will make a few other modifications to the shuttle that will give us another 1,000 to 2,000 pounds, so by taking these very modest steps we will be able to get a capability to get to 51.6 degrees.

Senator LOTT. Is that not sort of a stop-gap effort, though, in the long-term program?

Mr. GOLDIN. I think this will cover our needs to go get the space station launched and get the space station onto orbit. But we have a longer and more difficult decision to make as a nation, and that is are we going to be a spacefaring nation? But if we are going to be a spacefaring nation, we are going to have to face up to coming up with a system for robotic spacecraft launch and human launch that is much less complex, much more highly reliable, and much more robust and operational.

And there are a variety of approaches that we are looking at, and the President is undergoing a national launch strategy which we hope will be concluded by June of next year. And at that time we

will have to trade off making significant upgrades to the shuttle in our existing fleet weighed against some of the advanced technologies that Mr. Augustine was talking about. And we will have to invest. We cannot put off launch indefinitely.

I have watched from the industrial side as we put off decision after decision on launch. We are going to have to make a commitment, and I do not see how we could have a space budget that does not address launch. One of my deepest concerns is we have a number of safety improvements in there right now for the shuttle that the Congress has decided that we ought to stretch out in time. There are a number of upgrades that get pushed around because we have to deal with this instability in the budget.

So, the most important thing we do is near-term investments in upgrading the performance and reliability of the shuttle, and then a decision point at which we decide do we make a major investment in the shuttle so that its reliability is improved by a significant factor and its operating costs are reduced by a factor of two, or do we go to a new system?

Senator LOTT. Mr. Augustine, do you have any comment on the launch vehicle's future?

Mr. AUGUSTINE. Well, let me speak from the standpoint of our committee, if I may. We had felt that it was very important that the United States begin a new, expendable, man ratable, initially unmanned launch vehicle. And we had felt that way in part because it is only matter of time until we lose another shuttle, unfortunately. Statistics would suggest that. We should be prepared to deal with that eventuality.

Similarly, our existing launch vehicles were generally old technology and do require replacement at some point, and it will take years to develop a new launch vehicle. So, we were very supportive of beginning a launch vehicle.

As we look at NASA's budget today and as we look at the other programs that are starting, I do not think that our committee in good conscience could recommend beginning a new launch vehicle today because we were very critical of NASA trying to do too much with too little, and to begin a new launch vehicle at this point we rather suspect would be asking too much.

There is the subject of international launch vehicles which our committee did not yet express a view on, and so I really cannot speak to that. I would be glad to speak to my personal views, if you would care, but we did not address that.

Senator LOTT. Let me jump to another question because I do not want to keep the other members too long. Your Commission had recommended the development of the National Aerospace Plane, NASP, and you made the point I believe earlier that it is very important commercial aviation. We have had a heck of a fight in the Congress trying to get funding for it. I think we did wind up this year with a total of about $40 million, NASA and Defense.

Mr. GOLDIN. $60 million.

Senator LOTT. Is it at $60 million total? You still feel that this is one that we really should focus on and go forward on?

Mr. AUGUSTINE. Our committee was supportive of the technology of NASP. The view was that we should either do it right or not at

all, and to do a starvation development of NASP would probably be a mistake.

Senator LOTT. What was the answer?

Mr. AUGUSTINE. The answer is if you could put enough money in it to do it on a schedule where you will really fly a vehicle in a few years we ought to do it. If we have uncertainty in our willingness to do it, we ought to stop now.

Senator LOTT. Is $60 million enough of a commitment?

Mr. AUGUSTINE. You know, I am not trying to be evasive, but——

Senator LOTT. No, I know what you are saying. I am pressing you because I would like you to say, is it important enough that we go for the full funding in the next years to go ahead and do what we originally planned or not?

Mr. AUGUSTINE. Will you let me answer as an individual rather than our committee because our committee did not discuss the question you asked?

Senator LOTT. All right.

Mr. AUGUSTINE. As an individual, I would seriously question whether $60 million a year is enough to support a NASP program that will lead anywhere very worthwhile.

Senator LOTT. So, you are saying we need more?

Mr. AUGUSTINE. We either need more or we ought to stop.

Senator LOTT. All right, well, the question is: Is it important enough that we get more to go forward full thrust with it? Should this be a priority?

Mr. AUGUSTINE. Our committee felt it should.

Senator LOTT. All right, fine. Mr. Administrator, just a couple of other brief questions. On technology transfer, I think this is a very important area. It is an area where I know that NASA has tried to do more. I still do not think there is enough happening there. I know at the Stennis Space Center they are playing an important role in the remote sensing technology, in trying to transfer that to private and public sectors.

Are we going to focus more on that and try to get more done in the technology transfer area?

Mr. GOLDIN. Without a doubt. One of the directives that we put out was to establish that we should go from a reactive type of technical transfer—and let me define what I mean by that. We perform our programs, and then we put out tech briefs, and then people read the tech briefs and they can find some data. That takes a long time to get technology into the economy.

We are going to go to a much more proactive form. We were going to bring in the nonaerospace companies, and the aerospace companies for that matter, as part of our program planning process. And we have put out a directive that says technology transfer from the programs should be treated as importantly as our basic mission, so when we plan our mission we incorporate companies in it. So, I am very sensitive to what you said, and I believe it is crucial that we do that.

Senator LOTT. In view of the time and that we do have a vote on, if you would I would like for you to submit for the record an updated status of the negotiations with Russia, and our plans for the future.

Mr. GOLDIN. Yes, sir.

[The information referred to follows:]

Enclosed is a list of major milestones leading to Russian partnership in the international space station program and a description of the three phases of Human Space Flight Cooperation with Russia. In addition, since the question is not limited to Space Station and human space flight, also included are brief statements on the status of negotiations with Russia for cooperation in aeronautics, space science and earth science and environmental monitoring from space.

MAJOR MILESTONES LEADING TO RUSSIAN PARTNERSHIP IN THE INTERNATIONAL SPACE STATION PROGRAM

The major milestones with target dates are as follows:

November 7, 1993—Heads of agencies meeting with Russian Space Agency (RSA) in Montreal. (Completed)

November 9—Systems requirements review (SRR) for December 22 space station with Russian participation.

November 15—Initial technical briefing by NASA/RSA on Russian elements in Houston. (Completed)

November 17–19—Multilateral program coordination committees and agency working group to discuss any issues from the technical briefing by NASA/RSA, and partner comments on the addendum to the Alpha Station Program Implementation Plan of November 1, and to discuss and develop the integrated plan, a draft intergovernmental invitation and a proposed draft understanding for the interim period for Russian participation. (Completed)

Late November—Decision in principle by the governments of current space station partners to invite Russia to participate in the space station partnership; decision to be conveyed to the other space station partner governments through diplomatic channels in preparation for the December 6 intergovernmental consultations. (Completed)

December 6—Intergovernmental consultations; partners to issue joint invitation formally inviting Russia to become a partner in the International Space Station Program and to offer to Russia to enter expeditiously into negotiations and to charge their respective agencies to develop and enter into an understanding for the interim period. (Completed)

December 7—Joint invitation collectively conveyed to Russia via diplomatic note through embassies of the space station partner governments in Moscow. (Completed)

Mid-December Russian Government conveys its acceptance of the joint invitation via diplomatic note to space station partner governments through their embassies in Moscow.

December 15—Gore/Chernomyrdin Joint Commission meeting in Moscow. (Completed)

December/January—NASA/RSA interim agreement.

January 1994—Multilateral technical interchange meeting including RSA.

January 1994—Joint decision among partners on structure of agreements with Russia.

Early 1994—Intergovernmental agreement (IGA) and memoranda of understanding (MOU) negotiations.

March 1–23—System design review for space station with Russian participation.

APRIL 1994—Definition of operation and utilization concepts including each partner's roles.

MID-1994—Completion of legal requirements and processes for the IGA/MOUs.

MID-1994—Signature of the IGA and MOUs.

MID-1994—Initiation of the ratification process in capitals of participating nations.

SPACE STATION

The United States and Russia are embarking on a three-phase program of human space flight, beginning with use of the U.S. Space Shuttle and Russian Mir space station and followed by Russian involvement as a partner in the international cooperative Space Station program.

Phase One

On October 5, 1992, NASA and the Russian Space Agency (RSA) concluded the Implementing Agreement on Human Space Flight Cooperation, a program which began with the training of Russian cosmonauts for a flight on the Space Shuttle in January 1994. A Protocol expanding the terms of this agreement to include up to ten Shuttle flights to Mir, a total of 24 months time on board Mir for U.S. astro-

nauts, a program of scientific and technological research, and the upgrade and extension of the Mir lifetime during the period 1995-1997, is scheduled to be signed at the Joint Commission meeting. Phase One will provide valuable experience and test data to greatly reduce technical risks associated with the construction and operation of the international space station, as well as early opportunities for extended scientific and research activities.

Phase Two

Phase Two will combine U.S. and Russian components to create a human-tended orbital research facility. This facility will significantly expand and enlarge the scientific and research activities initiated in Phase One and will form the core around which the international space station will be constructed. Russian involvement will permit earlier Station operations than otherwise possible.

Phase Three

Phase Three completes the construction of the international space station, which will have a permanent human presence and full operational and research capability. The station will have an operational lifetime of approximately ten years. Phase Three will incorporate the technologies and capabilities tested and developed in Phases One and Two and will significantly expand the science and research activities of Phases One and Two.

An intergovernmental meeting was held on December 6, 1993, in Washington, at which time the U.S., Europe, Japan and Canada collectively invited Russia to join the international cooperative Space Station program. Following acceptance of the invitation, an interim operating understanding will be signed with Russia for immediate Russian involvement in the technical activities of the program, while negotiations proceed at both the government and agency-levels for Russia to become a full partner on Space Station.

AERONAUTICS

As called for in the Joint Statement of the Joint Commission issued on September 2, 1993, a NASA technical team visited major Russian aeronautical facilities, September 26–October 1, 1993. The delegation received excellent exposure to Russian design, ground and flight test capabilities.

NASA and its Russian counterpart, the State Committee for the Defense Branches of Industry (GOSKOMOBORONPROM) reached agreement in principle on seven cooperative areas in fundamental aeronautical sciences for initial implementation:

- Transition and Turbulence—Fundamental investigations of initial disturbance fields and their receptivity into the boundary layer at low and high speeds.
- Composite Structures and Materials—Fundamental investigations of advanced high-temperature composites, adhesives, and sealants.
- Chemically Reacting Flows—Fundamental investigations of chemical kinetic reaction mechanisms, turbulence closure for reacting flows, and computational modeling.
- Thermal Protection System Materials—Fundamental investigations of the catalytic efficiency and overall performance of heat shield materials.
- Environmental Concerns in Aviation—Research on the environmental effects of engine emissions on the atmosphere, in particular the ozone layer; generation, propagation and prediction of acoustic waves, including sonic boom.
- Hypersonic Technologies—Fundamental investigations of the controlling physical phenomena of hypersonic flight.
- Experimental Test Facilities—Use of ground and flight test facilities and test techniques for research on advanced aeronautical technologies.

Agreement was also reached in Moscow on establishing a Joint Working Group (JWG) on Aeronautical Sciences to manage the new cooperative relationship. NASA and its Russian counterpart agency, the Central Aero-Hydrodynamic Institute (TsAGI), would co-chair the JWG.

A Benior NASA delegation met in Moscow with GOSKOMOBORONPROM November 30–December 4, 1993 to complete negotiations on the text of the proposed Memorandum of Understanding (MOU) on Cooperation in Aeronautical Sciences, which was signed at the Joint Commission.

U.S.-RUSSIAN COOPERATION IN SPACE SCIENCE

Cooperation in space science is developed and implemented through joint working groups established under the 1987 U.S.-U.S.S.R. civil space agreement and continued under the 1992 U.S.-Russia space agreement. NASA's principal counterparts are the Russian Space Agency (RSA) and the Russian Academy of Sciences (RAS).

In Astronomy and Astrophysics, NASA is making significant hardware contributions—instruments and tracking stations—to the Russian Spectrum-X-Gamma and Spectrum Radio Astron missions; they build on the mutual strengths of the U.S. and Russian astrophysics programs. NASA and the RAS expect a substantial scientific return from these joint missions and have agreed that the highest priority should be placed on accomplishing them. NASA will also fly a Russian gamma-ray burst instrument, Konus, on the U.S. WIND spacecraft, scheduled for launch in 1994; this will be the first Russian-built instrument to fly on a U.S. spacecraft.

Current Solar System Exploration studies conducted by the U.S. and Russia give Mars high scientific priority because of the significance of Mars studies for understanding natural mechanisms which control past, recent, and future states of the terrestrial planets family, including Earth. NASA strongly supports the Russian Mars 94 and Mars 96 missions, which can contribute greatly to the achievement of major Mars science objectives. NASA and the RAS believe that a step-by-step process for bilateral Mars exploration collaboration should be developed which would include mutual scientific participation of Russian and U.S. scientists in each other's missions; flight of instruments, or their subsystems, on each other's missions (a U.S.-provided Mars Oxidant Experiment (MOX) is included on the Mars 94 mission); creation of a joint lander network on Mars, with possible international participation; and, establishment of a joint science group to study objectives for a possible joint Mars Sample Return Mission.

In Solar Terrestrial Physics, coordination of observations began between the U.S. Solar Maximum Mission and Soviet Phobos studies of the sun in the 1980s. The two sides will continue cooperative observation and data analysis programs using cosmic ray detectors on the Mir space station, and data exchanges on Anomalous Cosmic Rays. NASA and the RAS are discussing an agreement for tracking and recovery of long duration balloon flights launched from either North America or Russia, which will provide rich opportunities for upper atmospheric physics, cosmic ray physics, solar physics, and astrophysics.

U.S.-RUSSIAN COOPERATION IN EARTH SCIENCE AND ENVIRONMENTAL MONITORING FROM SPACE

As called for in the September 2 Joint Statement on the Development of Cooperation in Environmental Observations from Space, NASA, NOAA, the Russian Space Agency (RSA), and the Russian Academy of Sciences (RAS) have agreed to a plan for enhanced cooperation in studies of the Earth from space. The plan builds upon the success of the joint U.S.-Russian Meteor-3/Total Ozone Monitoring Spectrometer mission launched in August, 1991, as well as several small-scale ground truth campaigns. It emphasizes important Russian capabilities (satellite platforms, critical Russian ground data, and the Russian geography), American technology, and common scientific interests:

A) Joint space-based measurements, such as the flight of U.S. sensors on Russian spacecraft—plans are being studied to fly up to four additional U.S. sensors on Russian satellites in the latter part of the 1990s. The sensors will measure ozone and other atmospheric trace gases, and above-atmosphere solar irradiance. Integration of Russian satellites into the international Mission to Planet Earth program is also under study.

B) Capability enhancements for the coordinated receipt of data from existing satellite systems, to support specific scientific projects—the potential for installation of satellite data reception systems and upgrades to satellite tracking systems in critical regions are being examined. Up to three receiving stations for operational satellites are being planned for Siberia as a part of the International Geosphere-Biosphere Programme and the joint U.S.-Russia Taiga Aerospace Investigations program, using Geographic Information Systems Analysis. Long-term loans of precision tracking systems and other forms of technological cooperation for geodetic studies are envisaged under the Fiducial Laboratories for an International Natural Network program.

C) Establishment of common data standards and of catalog interoperability—these are prerequisites for the full exchange of operational and research data. Much of this work is to be accomplished under the auspices of existing international bodies such as the Committee on Earth Observations Satellites (CEOS). Specific bilateral initiatives will be examined, such as the development of shared data bases of ground and space data in support of Russian programs.

D) Sub-satellite experiments will be defined, involving deployment of airborne sensors and the conduct of ground truth campaigns, as well as correlative measurements programs based on the ongoing programs of the two countries.

Senator BURNS [presiding]. Thank you. I am just going to inherit this whole thing, I think, and everybody just bails out here on us.

The chairman had to leave. He went to go vote, and we will have a little dialog here until he gets back because I know he has some questions that he wants to ask all three of you gentlemen.

First of all, I am going to put my statement in the record today and thank you for coming.

[The prepared statement of Senator Burns follows:]

PREPARED STATEMENT OF SENATOR BURNS

Mr. Chairman, thank you for holding this hearing on the future of NASA. I think, from time to time, it is useful to do a broad top-to-bottom review of where the agency is now, and where it is going. It is not easy to manage billion dollar programs like the space station, Mission to Planet Earth, and the space shuttle. NASA consistently undertakes space challenges that other nations can only dream about. Notwithstanding that, the taxpayer has a right to expect that NASA's $14.6 billion annual budget is spent in a responsible, cost-effective way.

This hearing is about the future of NASA. However, whether we like it or not, the future of NASA seems unavoidably bound up with the $30 billion Space Station Program. It is NASA's most expensive and complex program and it clearly dominates our entire civil space agenda. For this reason, it is critical to the U.S. space program that space station is a success.

Several weeks ago, the Vice President was kind enough to visit with Congress and brief us on the plan for a United States-Russian Space Station. In effect, the plan calls for merging our Space Station Program with the second-generation space station that the Russians had already planned. Obviously, a United States-Russian space station has enormous potential benefits. NASA tells us that the United States-Russian Space Station will be a better station. It will have more living room; provide more electrical power for experiments; and accommodate a bigger crew than earlier station designs. In addition, it is gratifying to have former cold war rivals join forces for peaceful scientific purposes.

However, there are concerns about the Russian participation. For instance, I note that, of the first seven station-related launches, five are Russian launches of Russian spacecraft. I am concerned that excessive United States reliance on the Russians may leave the United States without a space station if the Russians drop out of the program. I also think it is important that Russian involvement not be allowed to reduce procurement opportunities for U.S. firms and their workers. Space Station Alpha does not help our Nation if it means station jobs in the United States will be transferred to Russia.

That having been said, it is important to give the new United States-Russian partnership a chance. This hearing is the subcommittee's first opportunity since the Vice President's space station briefing to review the new plan so I look forward to hearing more about it from our witnesses.

I also want to hear more about the ongoing reform effort to "Reinvent NASA." This reform is long overdue. The past several months have been difficult for NASA. Within that time period, three spacecraft—Landsat 6, a weather satellite, and the $1 billion Mars Observer—were all lost in space. The NASA's inspector general reported that he was unable to audit NASA's financial statement because its books were in such disarray. He also determined that sloppy procurement practices at NASA permit many contracts to be awarded without competition and allow some contractors to charge outrageous fees because NASA does not independently assess costs. Hopefully, during this hearing, this subcommittee will explore some of these matters.

Mr. Chairman, let me welcome our distinguished panel and I look forward to hearing from them today.

Senator BURNS. I noted with great interest, Mr. Goldin, your statement on R&D investment, that we continue to see R&D investment in the private sector slide down, and we are also pulling back a little bit here in the Government and its R&D investment.

I am particularly interested in the private sector. Why is that? Is that that they just do not have the funds, or our profit picture is not looking well enough that we can budget toward that? I al-

ways thought that our R&D funds were sort of set by a percentage of the overall budget.

Mr. GOLDIN. I believe that there has been a downswing in the economy. There is a need to remain profitable and it puts tremendous stresses on corporations. I know I went overseas when I was in industry and there were some countries I went to where I saw corporations making an investment between 9 and 12 percent of sales and R&D, and that was not anything close to my experience in our country.

And I think it has created an enormous problem where we are working on the near term without looking at the long term. And one of the places that the Government has made an outstanding impact on the economy is forward-thinking programs like the NASA program. You cannot see an aerospace industry in this country with the formation of the National Advisory Committee on Aeronautics, which was in sync and integrated with that activity.

And there was a cutback in that activity because of regulations and other problems, but also because of our R&D investment we are now seeing superior technology. It is not just subsidies in the international field. We are seeing better technologies coming out from some of our international competitors.

So, it is a very serious problem, and I think we have to look at it in a total industrial base. And let me give you an example that concerns me. Take a look at the aerospace sector, which I am very concerned about. There has been the commercial, the defense, and the civil space activity. And when defense was down and civil was down, commercial was up, and vice versa.

But now we have a situation where the commercial portion of our aerospace sector is down, the defense budget in space is dropping very fast, and the civil program is coming down very fast. It was not just 2 years ago when Mr. Augustine's panel talked about a 10-percent increase. Now we are trying to figure out how much in real terms the NASA budget is going to decrease.

We have not taken a look at this industry from a critical skills basis. I am concerned just about critical skills retention, and with cancellation of programs like the follow-on early warning satellite which we in NASA looked upon for the DOD to develop infrared focal plane technology which we could use for some of our Earth monitoring probes and our planetary probes, if there is not a major commitment to infrared technology by the Defense Department, I do not know where NASA is going to get it.

So, I am concerned that we have not taken a holistic look at what we are doing. We look at each program separately, but we have to take a look at industrial investment, commercial investment, defense, and civil programs to see where we have to go.

Senator BURNS. Give me an idea how we do that.

Mr. GOLDIN. I think that it is——

Senator BURNS. I mean, I would let all three of you remark. Give me an idea on what we should be doing as a Government, as elected representatives of our constituents, what should we be doing right now? Should we be conferencing? Give us an idea what we should be doing.

Mr. GOLDIN. I would say that there is a need for communication in the executive branch and the congressional branch so we do not

look at the world through soda straws. This committee looks at the civil space program. There are a series of defense committees that look at the defense program. There are other committees that interact on the civil program. It does not come together.

I think it is absolutely crucial that we take cross cuts through the industry to make sure we understand where we are going below critical mass. So, I would submit that both branches and industry ought to communicate better, and perhaps it may be desirable to form a cross cut panel of the executive branch and industry that could talk to a cross cut panel of the Congress.

Senator BURNS. I would say that most of your R&D—as you have indicated here today, you said that it should be mission-driven, and probably that is what we are going to have to do is to do something in the way of a communications seminar or whatever to sit down and maybe just—it is going to take a couple of days.

Mr. GOLDIN. It will take more than a couple of days. It will take quite a while. Now, there was a study that was done by the DPAC, it is an advisory committee to the Defense Department, and that committee got the industry together to take a cross cut look. I saw some of the results of that study and it was quite interesting in looking at some of these critical skills retention areas.

It is a good start, but I think this is something that might take on the order of a year to really flesh out.

Senator BURNS. And also if you look at your R&D right now, and if you are taking an overall look at this country—now, I realize that we are talking about NASA today and other areas— and if you had a limited amount of dollars and R&D has to be mission-driven, where would you be putting your dollars? And all three of you can take a shot at that if you want to.

Mr. GOLDIN. I would prioritize the dollars to make sure that they were being spent on advanced technology and not paying for bureaucracy and infrastructure as a first statement. It sounds trivial but there is a tendency in the NASA system to keep on going the way we are going. And any time you want to have some change there are a tremendous number of forces that come together to keep the status quo.

NASA must—must have new missions. This year for the first time we are starting four new small missions. All of them have advanced technology in them. But probably the mission—there are two missions that are overwhelming in capability. I would put a very high priority on the Mission to Planet Earth. That is rich in very, very good technology and it is rich in all the things that will make us a strong spacefaring nation, and rich in technology transfer.

I would put a very high priority on the aeronautics. Aeronautics takes us to the cutting edge in materials and computation and informational systems, and that is the second place.

The third place that I would put it is into the science on the Humans in Space Program and on the space station. Rather than just focusing on the infrastructure for the space station, I would put the priority into the science and technology that goes on the space station, and we need a lot more focus on that. Those would be my three highest priorities.

Senator BURNS. I am going to turn this over to the chairman. I am going to make a little statement here.

I agree with you and with Dr. Frosch here that we have got to watch the watchers watch the watchers, and agree with what Mr. Goldin says. Once a contract is given to a company or corporation to perform to a mission and then how that links to technology transfer because they not only know the application in space but they also understand that this has great private sector possibilities too and know how to market it. So, I like that statement and, of course, your long-term planning.

Thank you very much. I have got to go vote. I am going to turn it over to the chairman. And I would ask permission to put my statement in the record. You are a nice fellow, and thank you for showing up. [Laughter.]

Senator ROCKEFELLER [presiding]. Dr. Frosch, I apologize because I was not here at the beginning and I was not here for the statements. And I just came back from a vote, but that does not presume that I do not have questions to ask.

You were vice president of General Motors for research for more than 10 years.

Dr. FROSCH. Eleven years.

Senator ROCKEFELLER. To what extent, and how would you describe the contribution that NASA has made to the auto industry or to American industry in general, in terms of the technology which can come under the frame of competitiveness useful?

Dr. FROSCH. OK. Not in the terms that are usually described.

Senator ROCKEFELLER. Could you pull the mike up a little closer, sir?

Dr. FROSCH. Not in the terms that are usually described, but that is true of all technology transfer. That is, everybody is looking for the possibility of saying: NASA built a widget for a spacecraft and, look, we put it in a automobile. That is not the way it worked.

It was extremely important that NASA commissioned and developed the first real computer capability to analyze structures for the way in which they deform, bend, and crush. That resulted in a computer program system called NASTRAN that was the beginning of an entire modern capability to analyze structures as they fail and, in fact, is the singular basis for the current capability of the automobile industry to analyze safety and crush. It is still, in fact, a primary program, although it is not the only one.

There were a number of cases in which the more subtle forms of science and technology that NASA developed came into use in the industry. There are influences of the NASA work, particularly in the aeronautics side, but also on the space side, in the technology of composites and composite structures and how to create them, how to analyze them.

Even though many of the composites NASA pioneered with its contractors are expensive high-technology polymers that are not yet easily applicable in the automotive industry, yet the underlying understanding of the materials, how to design materials, and how to use them, and what the underlying chemistry and physics is, has been very important to the industry.

I think that is a general lesson. When one talks about mission-oriented R&D, one has to understand that it is not just the imme-

diate technology which is called out by the mission, but all of the underlying technology that needs to be developed, and the underlying science. You cannot do computational analysis of structures just with a computer program. You also need a mathematical structure underneath it; you need to go on with the chemistry and the physics. So, mission-oriented research requires a certain amount of not so clearly mission oriented science and technology development.

Senator ROCKEFELLER. Yes, but that is a very clear and a very important answer. I mean what you are saying is that people who want to make a direct line between point A, being NASA research and development, and point B, being, let us say, a General Motors application, that is a false standard of judgment.

Dr. FROSCH. You need to make a kind of a complicated zigzag examination of what really happened.

Senator ROCKEFELLER. But that is a very important and a very clear answer.

Dr. FROSCH. I would like to make one other comment about it.

Senator ROCKEFELLER. Yes, sir.

Dr. FROSCH. That zigzag line that connects the two may be a fairly long line in time. That is, it may not be something that happens in the course of 6 months or a year. You may have to look back over 5 or 10 years of history. There is a lot of technological history now that suggests that introducing a new technology into industry; namely getting it broadly adopted, always takes something of the order of a decade or a decade and a half. Not to begin, but to get it fully integrated into industry.

Senator ROCKEFELLER. I totally understand. This will sound frivolous, but it is not meant to me.

A major new emphasis on the clean car, and so much so that Detroit, which has traditionally backed away from Washington, and Washington, which has traditionally backed away from antitrust issues or whatever, all of a sudden there is a sense of cooperation, to build a clean car. Purely out of curiosity, is there anything, to your knowledge, that has, generically or in a zigzag fashion, been done or being done by NASA that could be helpful in the development of a clean car?

Dr. FROSCH. I would expect that some of the work which has been done—I guess particularly by Lewis Research Center, but also by other NASA centers—in combustion and in the chemistry of propulsion materials has, in fact, been incorporated in some of the combustion analyses that are done in the industry, and are likely to continue to be of direct use in that.

I certainly know that——

Senator ROCKEFELLER. You mean that it could proceed unchanged or with the same basic premise, into the clean car?

Dr. FROSCH. What it does is give understanding and insight into the chemistry and physics of combustion, which you then use to understand combustion in the conditions inside an automobile engine, even though it is not exactly the same as what is in a rocket motor.

There is also a whole class of sensors which are based on some of the sensor ideas that were developed for Earth sensing and some of the spectrometry that was developed for deep space sensing. Again, you do not take the device that was built for a satellite and put it into an automobile factory or an automobile engine, but the

basic ideas are important to stimulate and to provide new avenues for technology.

Some of that has come through rather complicated ways. There is now a very simple sensor being used in GM plants for a measurement, whose history is that it was redeveloped by a team of GM research labs people together with Hughes research labs people. The Hughes people did the original work for a space sensing mission which was connected with both a Defense and a NASA mission. So, you have this devious path, but that, in fact, is where the science and technology came from.

Senator ROCKEFELLER. Dr. Frosch, I thank you, and I will come back to you.

Dr. Goldin, the—interestingly, back in 1958 when Congress enacted the National Aeronautics and Space Act, it was mandated that NASA disseminate information on its technologies.

You fully recognize that this country is trying—and that will lead me to a question to Norm Augustine. This country is trying now to get a sense of priorities in terms of NASA. But crowding into that sense of priorities increasingly is, with the scarce resources and the sense that other countries are pulling ahead of us in very critical technologies, a new kind of pressure to have NASA serve the American future in ways other than just associated with space exploration, manned space flight, unmanned space flight.

You do not run away from that. You welcome that and have said so before. Now, let me add on two other constructs. One is that we passed this year a half-trillion dollar deficit budget reduction which seemed to pass relatively unnoticed, and we are about to do another anywhere between $10 to $100 billion. And thus the future of money available in general in the Federal Government is reduced, hence more pressure on NASA.

Take it to another level.

We were facing a vote on the balanced budget, a constitutional amendment in the next 5 or 6 or 7 days, and what that would do would be to call for zero budget deficit by the year 1999. Well, you could imagine what would happen, for example, to health care reform. We would not have it because Medicare and Medicaid, all those sources of funding would have disappeared. You can imagine the pressure that would put on NASA. Would NASA ever survive under a formula where you could only be let out under national emergencies or by three-fifths vote in the House and the Senate?

Now, having cheered you in this manner, how, honestly speaking, do you look upon this question of the commercialization of technologies that might—that can be learned through NASA, only in NASA in its operations, whether up in the air or not, and the increasing pressure to make those available to the betterment of the American condition of living, which might be quite apart from the historic mission of NASA?

They are in some fundamental conflict. And if you are purely driving for certain achievements in NASA and these are gradually and increasingly thrust in on you, commercialization of technology for the general good of mankind, there is a very either creative or uncreative tension in those. You have decided to accept that challenge, because there almost is no choice. But there must be a sense of foreboding in you that pressure will increase, and that the pure

mission of NASA, as we would think of it, will be increasingly threatened.

Bare your soul, sir.

Mr. GOLDIN. Well, let me start by saying I had a very happy event happen in my life last week—it changed my perspective on life—that I had my first grandchild. And as I sat thinking about the future for that grandchild, I thought about all these conflicting things you are talking about, not just in the Government, but where is our society at. And I think the question is deeper than you have posed.

The question is what are we as a society? Are we a society of people that are trying to survive—and when you talk about technology transfer, you talk about things that have, I am sensing, an impact that I would say for today, tomorrow, next year, or 3 years from now.

Senator ROCKEFELLER. For example, the telemedicine demonstration which we had a week ago, right?

Mr. GOLDIN. For example, telemedicine. I want to say to you that I worry about the future for my grandchild. I worry about our generation that has built this enormous problem in the economy, and the way we steal from the future to live in the present, that we do not reinvest in that future.

So, the issue for America is not a gimmick where NASA is going to try and make it through the next 5 years and say I am going to do something and it is going to help America survive in the next 5 years. America has to decide do we want to take some fraction of our budget, however small, and say we are going to invest for 20 years downstream so we can have an NASTRAN model.

I cannot predict for you that the next NASTRAN model is going to come out in a year or 2 years from now. It is a fundamental issue that requires a long-term focus and vision. What does America stand for, and do we want to invest in the future?

Now, if NASA is going to be converted specifically to justify itself just on its technology transfer, cancel the agency. What NASA is about is about a commitment to the future and pushing back the barriers to the mysteries in space and air travel, and that has to be the underlying principle for NASA.

Senator ROCKEFELLER. And I am totally agreeing with you. But what I am trying to probe is your sense of concern as a Congress and an American people who are increasingly driven by improvements in their life in the short-term future, who are increasingly unwilling or unable or unschooled to think in long terms, in longer terms, that that pressure reflects itself through us as a body.

The Senate is acting much more like the House, and that is that we are in a position now because of the general sense of the rejection of Government as being a useful force in people's lives.

I mean you can argue as to social security and the invasion of Normandy Beach and the Interstate Highway System but, you know, that does not immediately occur to people. People, in a sense, kind of reject the Government as being fundamentally useful to their lives, and it takes money out of their pocketbooks to boot.

So that the pressure for results and results—it is the same kind of pressure that makes it very painful for you when something does not work out in terms of a launch, when you and I both perfectly

well know when you are doing something extremely complicated, that the chances of that happening are very substantial. And, in fact, when I went down to, as they used to say, Cape Canaveral, to watch a launch, the launch did not work. And it was far more effective and interesting to me, in terms of learning about NASA, that it did not launch, in which everybody was discussing what the problems were, than if it had launched.

But you understand what I am saying. The pressure to deliver and the pressure, as in this administration, to make technology work on a shorter term basis for the American people, even dipping into the reservoir of NASA. With the shorter funding confidence that we all have, this somehow has to crowd in on you and make you nervous, even as you accept it because you have to and, perhaps, want to.

Mr. GOLDIN. The fact of the matter is we have to do it. But, again, I come back and say you must have a long-term focus and try and satisfy the near term as much as possible. And I will say the budget came down and down and down.

Senator ROCKEFELLER. Right.

Mr. GOLDIN. And we reacted to that. We have maintained our basic programs. One more budget cut, and we are going to have to cut out a basic element of the NASA program. We cannot stretch any more. And I am concerned that we are very close to the edge of the cancellation of our planetary program.

Senator ROCKEFELLER. Of your which?

Mr. GOLDIN. Planetary program.

Senator ROCKEFELLER. OK.

Mr. GOLDIN. That is probably going to be the first program that is going to suffer if we have some more cuts. The astrophysical program will suffer. But we cannot keep spreading and spreading. We have to make a decision to cancel if that is what America wants to do, however sad that is.

So, if we get pushed, we cancel. That is what is going to happen. But what we should not do—I want to keep coming back to this basic high-ground issue. We should not try to sell to America that NASA will be the cure-all to the economic problems of today. NASA can help with it. I believe that NASA could do a lot of things relative to the clean car, along the lines that Dr. Frosch talked about, but that clean car is 10 years away.

The tools we will develop are tools that will not be developed by the themselves. The telemedicine that you saw, that you saw in real time working on real people, would not be there if we did not do it. So, my answer to your question is of course we will react, and we are not going to be recalcitrant and say we cannot do it. But we have squeezed all the fat out and now we start cutting bone, and what we do is cancel.

Senator ROCKEFELLER. And what interested me about the telemedicine—and I will just explain to Norm and to Dr. Frosch. That was a demonstration basically where a physician in the United States was evaluating a kid somewhere in Russia directly, in consultation and with translation with the Russian physician who was there. And they talked back and forth and they diagnosed, and then there was diagnosis from Washington to within the United

States of America, just showing the power of what can be done with technology.

But do you understand what the message of that was, Dan? That the message encouraged precisely the kind of thinking that I am talking about. I mean here the man was already here, presumably, in the United States. You were there, the head of the program. It was this enormous array of excitement and power and immediacy, but it was about improving life today, making the life of Americans better today. And in a sense even by encouraging the prospects of NASA, the points that you were making were not what you would call the pure mission points, but rather the spinoff points.

Mr. GOLDIN. But, again, the spinoff is on-the-margin benefits to the world. I am concerned if we try and change NASA's mission so that it is focused 50 to 70 percent on spinoffs and 30 percent on mission, if we do that we will not have a space program.

Senator ROCKEFELLER. Absolutely.

Mr. GOLDIN. And that is the point I want to make.

Senator ROCKEFELLER. All right. Would you just state for me again your sense of the priorities of NASA, of the way this $14.5 has to be spent? I have the figures here before me how you plan to do it, but put it into words.

Mr. GOLDIN. Let me put it into words. I would say that among our highest priorities is Mission to Planet Earth for a variety of reasons. It is rich in technology and it is rich in rewards in terms of what we will learn. That knowledge is not going to come in a year or two, that knowledge will come over a decade or two, and we have to be patient on that score. But if we stay the course, we will learn a tremendous knowledge base about the human and naturally induced impacts to our environment so we can make policy decisions, and at the same time develop a very rich, robust technology.

Our second priority is to continue humans in space. We have to—we are at a deciding point here. Now is the time to decide are we going to have humans in space? If we are, we have got to stop debating it. I have been the NASA Administrator for a year and a half and we have had 9 votes, and I think next Saturday a 10th vote is coming up. We cannot go on this way any more. A commitment has to be made. The morale is a disaster. And if we do not make a commitment, let us not get involved with other countries and ask us to join us and then one-half year later walk away from them.

So, this is the deciding point. This year, now, we decide to have humans in space. If we want to have studies and trades and nice discussions in the Congress, we could keep it up and we will waste the taxpayers' money. We want to build hardware, we want to launch it, and we want to start getting a laboratory up, and now is the time to decide that.

We ought to focus it mainly on science and technology and the understanding we get from the laboratory, and not on the infrastructure we put up in space. We want to learn how humans live and work in space. We want to learn how we can do microgravity research. We want to learn how to get spacefaring technologies. These are the things that will accrue from a space station, and it will prepare us for the next steps that will come beyond. Time

marches on, and our society has got to understand that we are not going to stop exploration. We could slow it down but we are not going to stop it.

The third priority is the aeronautics program. Aeronautics is probably the richest technology field we have in NASA. The opportunity in computational fluid dynamics, information system development, materials, understanding of combustion, fluid flow, systems integration, large difficult systems. The weakness in our program right now is it rich in technology but, as you and I have talked about, we need some experimental aircraft. We stopped that program decades ago, and I think this has a serious impact on our aircraft industry.

So, I would say that we must take a good hard look at what we are not going to do to make *x* planes available. And one possibility is we could——

Senator ROCKEFELLER. Can I interrupt you? That is a very interesting statement, that you may have said to others who are here, that we have paid a price in terms of our airplane and air flight industry because of what we stopped doing in NASA let us say a decade ago. That is a very interesting statement because it is objectively true that others have become much more aggressive. Now, whether or not the NASA cessation of activity in that area was—I mean the Japanese were going to do it anyway; others, the French and the Europeans, were going to do it anyway.

But that is a very interesting statement you just made. What did we stop doing that hurt?

Mr. GOLDIN. We stopped building wind tunnels and developing new facilities.

Senator ROCKEFELLER. And so now when the——

Mr. GOLDIN. We stopped doing basic development. We stopped writing computer codes, we stopped looking at new materials, and we did not work in concert with the aircraft industry to the level that we should have.

Senator ROCKEFELLER. Which is a classic thing, because what, in effect, you are saying is—and correct me if I am wrong—that now when Boeing and these giant commercial aircraft industries do their wind tunnel experiments, I think you told me that they do it in miniature, that they have a little tiny wind tunnel.

Mr. GOLDIN. They do it in Moscow and Amsterdam.

Senator ROCKEFELLER. They do it the right way there.

Mr. GOLDIN. Yes.

Senator ROCKEFELLER. That is where they have to go, in other words.

Mr. GOLDIN. Yes, sir.

Senator ROCKEFELLER. But when we do it, we do not have that, and we did not—what we have is 30 or 40 years old, right, our wind tunnels?

Mr. GOLDIN. This is correct. And they are not productive and they are very expensive to operate. And the critical item in wind tunnels is cycle time. When you want to bring a plane to market, you have a new idea, you have got to get it there fast. If I spend an extra year testing in wind tunnels because I have antiquated wind tunnels, I lose out to the other countries.

Senator ROCKEFELLER. Yes. And it is a fact.

Mr. GOLDIN. Among our other highest priorities is space science. I mean, that is what NASA was born to do, planetary science, astrophysics. It is absolutely crucial.

Those are the four core issues that I think are what NASA has to focus on. And what we would like to do is keep all four of those in balance, and it gets more and more difficult with each budget cut. And I talked about the fact that we took the budget down from $106 billion over a 5-year period to $78 billion, and I am tremendously proud that we were able to hold the fundamental program together.

Senator ROCKEFELLER. Yes, at that.

Mr. GOLDIN. I am worried about further stretches.

Senator ROCKEFELLER. So, you cannot do it another year. You cannot go through this another year.

Mr. GOLDIN. There are no more rabbits in the hat.

Senator ROCKEFELLER. Norm Augustine, you have been—and I am delighted you are here and have enormous respect for you. You have been watching this. You have written about it, you headed up independent commissions analyzing the space program. The problem of picking priorities is hard for Americans.

In fact, I do not know, at this point I guess I want to kind of make an analysis or comparison with health care. Health care is an enormously complex subject. This goes over into the whole question of NASA, which I think is one of your basic problems, and that is ignorance within the Congress. You have not said that, but I think it is true.

That there are probably 20 to 30 people, maximum, out of 535 people in the Congress, who have any kind of a reasonable understanding of health care public policy. They do not understand it, the words, terminology.

But on the other hand, health care touches everybody. Every family is affected by it, or the lack of it, or its problems or its deficiencies. So, there is this broad commitment—and not just recently, it has been very active recently but it has been going on for a long time—to how do we make this better. People are willing to do it because it touches everybody. NASA is much more discreet. It touches everybody eventually, including in health care, witness our doings of last week.

But, Norm, in America we have a terribly difficult time establishing priorities. It seems to be against our national characteristic. It's partly because you get a little bit of everything, that everything is your right, you do not have to pay for it, it just is there for you. And if you do, you gripe, but you have to pay for it and you pay and you go ahead and get it.

But we are not by nature analytical and that comes, I think, from several reasons. One is that we are this huge continent. We never had to think of ourselves as having limits. Having limits and being an American is a relatively three-decade old problem. And it carries over classically to NASA.

Started in 1958 and you go to John Glenn and, you know, this incredible period when Americans thrust themselves, they could not do enough for NASA. And everybody harkens back to that period fondly, knowing full well that it can never be created again because Americans cannot get excited as easily by doing the same

thing the third time as they can the first time. In the meantime, other new elements have entered, but Americans not being duly informed either by their media or by their political representation, they somehow cannot get into it.

My question to you is sort of philosophical. Why is it, do you think, that we have such a problem in this country in establishing priorities on difficult subjects that are of enormous importance to the country? And specifically, why is it other than budget cutting, that we have had so much difficulty in establishing priorities for NASA?

Mr. AUGUSTINE. That is a very profound question. I think you touched on part of the answer, which is that for at least the last century Americans have had the good fortune of not having to make very many tough choices. We could afford to do most of what we wanted to do. We had the financial resources, the technical resources, the energy resources, and only more recently have we been forced to learn how to make choices, and we are learning that it is hard to do so.

I think a factor that makes it particularly difficult in NASA's case is that we make "priority" choices one year at a time. We do not really make priority choices. For example, in my private life, if I were to decide to build a home, I would go to a builder and ask them to build me a home. In the space program, you go to NASA and say "build me 1 year's worth of home, and I will see you next year and tell you what I want next year." And so you never do face the real priority tradeoff with the resources necessary to carry out your goals. We do it a year at a time, and we get ourselves into blind alleys that we cannot get out of because we commit to too much.

And so it takes a great deal of self-discipline to not start things that, in the long term, we cannot complete. I think a key ingredient that is missing in our prioritization process is that we should be budgeting program by program, not year by year. And until we face that reality, I suspect we are going to continue to find the kind of difficulty we have now.

We have had great successes. Take the discussion you and the Administrator were having about competitiveness: NASA has contributed and it is important to remember, not only in terms of basic technology, things like combustion technology, computers, optics, materials, and so on, but also it was NASA's predecessor that built the U.S. jet aircraft industry, or, more accurately, the U.S. aircraft industry, which until a few years ago built 90 percent of the world's commercial jets. It is NASA that has built the world's space-based telecommunications industry. It was NASA that built—with the help of the Air Force—the launch vehicle industry in this country.

So, there have been cases where the prioritizations we have chosen in the past have paid off through technology. There have also been direct payoffs in applications, whole new industries have been created. And I suspect that until we put our choices in a form where we have to make the trade of the entire investment with the entire payoff at one time, we will find ourselves perpetually in this agonizing situation we are in now, where 10 years ago we committed to more than we can afford to pay for today.

Senator ROCKEFELLER. So, there is no way out, in a sense, because what you are suggesting is that we make our choices negatively. And you have made positive recommendations, Dan; but as we decrease the amount of money, it is under those circumstances then that we have to decide what to cut out.

But then, that is what Dan Goldin is saying, the American Congress or the American people's suggestion would be: Continue to do all four. Not knowing that you cannot do four at that level, you can only do three; the American people not understanding, the American Congress not understanding.

In fact, the hard choices that we decide for you have to be made; and we are not necessarily in a position to make those choices.

Mr. AUGUSTINE. I think there is a way out, and the way out is, for the Congress and NASA, much as Mr. Goldin has suggested to agree on a basic level of funding that could be preserved with some stability; and then to design a program that fits that level of funding. We can do that. But if each year we change the budget by 20 percent, up or down, either way, we will continue to be in chaos.

Dr. FROSCH. Mr. Chairman, I wonder if I could comment on that.

Senator ROCKEFELLER. Please.

Dr. FROSCH. What Norm has just suggested is somewhat closer to the political spirit of the time when I was Administrator.

It certainly was not the case that there was a formal process that says NASA gets a certain amount of money, and then we will figure it out. But there was a kind of informal process, in the course of which there was a long discussion about what the realistic budget prospects were, followed by a discussion of more or less how the Congress wanted it divided up.

This was greatly helped in some areas, as in the shuttle, by the fact that there was a strong treaty between DOD and NASA, over space transportation, which subsequently came totally unglued, so that a political and a technological alliance that was important vanished.

This did not mean that everything was simple and smooth; but we had a much better sense of what was possible. I think we had a much better sense then—I am getting that from this discussion—of what it was the Congress would support, and not support. That extended even to the fact that in difficult fiscal times, when we ran into some troubles in developing the shuttle, it was possible to come back to the Congress, even in poor years, and get additional funds, because there was an underlying agreement that we were going to complete the shuttle.

Senator ROCKEFELLER. And because the funds did not start to run out in this country, so to speak, until about 1979, halfway through your term.

Dr. FROSCH. Well, I think it was not as difficult a problem, but we were certainly under fiscal pressure. But at least in that era, the pressure perhaps was not so high, and the Congress informally, took a longer range view than it was perceived to take formally. I think now, informally, it does not take a longer range view than it is perceived to take.

Senator ROCKEFELLER. And then, let me ask—Dan, I hate to ask you this question, because then you would have to answer it. Well, I can make it generic.

I indicated a moment ago—and I am just trying to do this, to put this in some perspective, and frankly, to get some of the blame off of you and NASA. I indicated a moment ago that I felt there were a maximum of 30—I really feel it is more likely 20—of the 535 Members of the U.S. Congress, who understand in some degree of substance what I would call something called health care policy.

The same question, I put to you: In terms of those who understand space exploration, NASA and the, to a relatively substantive degree, the intricacies and the choices that are involved within that program, how many folks—no names—how many folks would you say there are, in the U.S. Congress? I am going to put to you, the No. 7. Would you go over that number?

Mr. GOLDIN. I think you are off by a factor of 2.

Senator ROCKEFELLER. Over, by a factor of 2, or by 2?

Mr. GOLDIN. I would say 14 or 15.

Senator ROCKEFELLER. Fourteen or 15?

Mr. GOLDIN. And let me say the reason for that. I think it is different than health care.

NASA has gone from one stable state, and we are in the process of change now. And the thing that makes people crazy is dealing with the chaos of change. People like order. People, when I go to see them—and by way, I have personally been with, maybe, 300 Members of the Congress, sitting in their offices——

Senator ROCKEFELLER. I believe that.

Mr. GOLDIN [continuing]. And a lot of them understand the space program, in the perspective of 1960 and 1970; and they have these fond memories of watching Apollo land on the Moon, and they understood it. And they are terribly confused by what they see now.

So, I think it is a little bit different than the health issue, which has been constantly in change. We are going from one state, and we have not transitioned, into the new state; and there is this tremendous desire to have order. And it is OK to have some chaos as you are going through this transition.

That is hurting us more than anything else, in our ability to communicate.

Senator ROCKEFELLER. Other than the political ramifications, which is a big "other," what are the advantages of having nine field offices and one central headquarters?

Mr. GOLDIN. There is an advantage to having nine field offices, if each field office is a center of excellence. And let me tell you what I mean by a center of excellence: Best in the world, in what they do.

If each field center has an overlap, and they do the same things, there is no benefit; other than political.

Let me tell you the problem we face: I have asked the NASA employees to come together as a team; and I have asked the top managers in NASA to take it upon themselves to start reviewing roles and responsibilities. And you can never leave the political aspect.

They were gathering together—I did not even participate in the meetings—they decided to do this themselves. I said, "Please feel empowered." And Jack Daley and the center directors and associate administrators got together on a regular basis, to try and see if they could sort through these roles and responsibilities, working out theoretical possibilities.

Unfortunately, they put it on a piece of paper. The piece of paper went to the press. And I have been inundated with letters from the Members of Congress, responding to their constituent needs.

But we have to keep in mind, coming back to the high ground: The purpose of NASA is not to employ people working for NASA; the purpose of NASA is to do bold and noble things that improve the quality of life in the near and long term. That is what we are supposed to be doing.

So, the mere process that NASA was even wanting to talk about roles and responsibilities, to build centers of excellence around the agency, was dampened a bit by the tremendous press we got by the fact that we just wanted to talk about it.

And I submit that, unless NASA—we are the world's most open agency; we do not have secret documents, we do not even tell people, "Do not talk to the press." But, unless we could have open dialog among ourselves, without being inundated—and you know, we deal in a political world, so we do the best we can—it does quench the process.

And the message that everyone got was: Back off, and go back to where you were, and do not take risks; because if you take risks and start dealing with difficult subjects, you are going to get some stress.

So, we talked about what the Congress might do. The Congress might have a little more flexibility in interacting with us, so that we could have dialog on these subjects, without causing people to back off and being afraid.

I want to tell you, I have a bunch of senior managers that are really gunshy, and they do not want to touch this with a 10-foot pole.

Senator ROCKEFELLER. Norm Augustine, the Congress, not with my vote, turned down the supercollider. Now that is a very different kind of science than something called NASA. They did so in a—it was kind of like a revulsion. It was like America had to act, to make some statement, to show that we were getting a hold on things. I do not think it was to punish Texas, and all of that.

But we did that. And presumably, an enormous array of future, probably long-term, but heretofore unexplored verities will never come to light; in that I doubt that we will ever again undertake a physics project of that magnitude. This Government will never do that again.

Is there worry that this will happen to NASA? In other words, that somehow the instinct of the Congress, was to pick on something that had a big number, and simply say, "OK, we are going to get rid of that"?

It is my analogy to the balanced budget amendment, which I think is a catastrophe for the Nation; and most of your fellow CEO's across this country would disagree with that very strongly. They think probably the Federal Government should do that. I do not, because of what would happen to things like health care and NASA, and I wonder whether you can take that much money out of the economy? But the willingness—without results, damaging results to the economy?

Is there a comparison or a lesson to be learned, or a danger to be worried about, between our willingness to close down so sud-

denly, the supercollider, having raised it on a pedestal for a period of years? And anything you see, pertaining to the future of NASA? Or am I just on a wild duck chase?

Mr. AUGUSTINE. I think you raise a concern that is worthy of some consideration. The economic health of our country, which really underpins our way of life, our quality of life, is obviously dependent upon our competitiveness in the world today. And our competitiveness in the world today, I would submit, is dependent very heavily on research and development.

Many of the leading products that our firms in this country sell today, did not exist 10 years ago. The reason they exist now is because we committed money to research and development.

Our Government has reacted at least in one case that so-called big science is bad; and has dealt with the superconducting supercollider the way you described. I find that unfortunate. I think a judgment that big science is good or bad, or small science is good or bad, would be too much of a generalization. Some big science is good, and some big science probably is not so good.

But it is not only the Government that is reacting that way, and we talked a little bit about this earlier. Within the private sector, we see cutbacks in R&D spending.

Senator ROCKEFELLER. Now that used to be the first thing to go. But in this new round, over the last 3 or 4 years, is that still the case? I thought there was a broader way of thinking, a more intelligent way of thinking, in these cuts.

Mr. AUGUSTINE. I would not attribute any additional intelligence to the CEO's in this country in the last few years. [Laughter.]

Senator ROCKEFELLER. Well, that is very depressing, because that, again, shows this is an American characteristic.

Mr. AUGUSTINE. What I think we are finding is that American industry is responding to the pressures of the market. Not many people are aware of it, but the average company in American turns over its entire ownership every 2 years, on the average. So, the people who own your company today, on the average, will "all" be gone 2 years from now. And R&D, as you know so well, has a payoff that is measured in 10, 15, 20 years.

And if I could take just 1 minute to describe a little incident that occurred in our company 6 or 7 years ago, when we were very excited about some additional R&D we were going to do.

We were going to increase our spending. We were so excited, we sent our president to New York, to brief the financial people. He briefed them, and they literally ran out of the room, to sell our stock. Our stock dropped 11.5 points in 5 days, and slid for 2 more years. And when we asked them, "Well, why did you do this to us?" Their answer was that the things we were talking about investing in; namely R&D, would not pay off for many years; and they did not want to have anything to do with management that was so shortsighted.

And to the great credit of the people who then ran the company, we went ahead and did it. But the pressure is all on reducing R&D, because it has such a long payoff.

Similarly, consider our universities. I serve as a trustee of a couple of universities. Our universities are very concerned about the basic research that they do, really, the lion's share of research in

this country. The reason they are so concerned, of course, is Government support of basic research is being cut back.

And so we find Government support for large science being reduced; we find industry reducing its research; and we find our universities reducing our research. And that suggests to me that we are taking the engine off of the train that we have had running along for so many years.

Dr. FROSCH. I would put it that the mood of the country is to desert its future, and not bother with it. And I think that is a very serious problem. I think the SSC is a symptom.

Just parenthetically, I think one has to be careful about the definition of "large science." I did a very short analysis and put it in a letter to the journal, Science, in which I looked at the question of the cost per principal investigator over the prospective cost and life of the SSC, as compared to the cost per principal investigator to do oceanography, which I happen to know something about and could do an analysis of; and the cost per principal investigator of the GM research laboratories, which is pretty much small science, in the sense that it does not have large capital expenditures.

The SSC cost per principal investigator per year was around $350,000; the cost for oceanography was around $300,000 or $325,000; and the cost for the GM research labs was around $300,000.

I suspect, although I have not got the numbers and it is difficult to get them, that if you got the numbers for university researchers and really reduced out the time and the time commitment, you would not get very different numbers. They might be different by a factor of 2, but not by a factor of 10.

So, the difficulty with the SSC was not that it was so much expenditure for so few scientists, but that it was so much expenditure in a lump; which had to be a long-term future commitment. I think that is what the psychological problem was.

Senator ROCKEFELLER. Let me ask a final question of all three of you; and if all three of you would answer, I would be grateful.

I count myself among those who think that one of the reasons that one does, for example, the space station, and that one continues on in an era of brutal budgetcutting, that one continues is because NASA stands there as a beacon.

And the word "beacon" is useful. And I have said this a number of times before in hearings: That I am neither a mathematician, nor a scientist, nor ever showed any strong inclinations toward becoming such. But I believe thoroughly that, in order to be a scientist, in order to be an engineer, kids have to have it in the back of their minds by about the time they are 12 or 13 years old, that that is what they want to do.

You look at American industry, and you look at where the engineers are in the corporate structure. They are not at the top, for the most part. That is one of the things, I used to say that two-thirds of Japanese CEO's are engineers or mathematicians, and one-third of American CEO's are.

And I do not know what the ratio is now; but I suspect that the youngster just beginning to be serious about life, like my 14 year old, who is pretty good at math and science, that he looks around

and he sees that the engineer does not do that well in the corporate ladder, just from the financial side.

Change of scenery: Americans react uniquely, I think, to inspiration. Sometimes uniquely in the wrong ways; we rush to conclude something wrong. But we are a nation that needs to be lifted beyond our own selves toward a vision of something else. And it has to do with, I am sure, our religious heritage, the size of our continent, our general recently compromised great degree of self-confidence, and our intrinsic interest in the "new," new inventions, new directions.

That process starts, for the most part, during the teenage and early teenage years. And that one of the ways that NASA, the space station, and other science projects can be justified, is that America has to have something like that.

We had this fascination a number of years ago, about: What was the tallest building in America? We look at that. We measure the lengths of home runs. We are just that way, as a people. And we hero worship much more than others do.

My question is too long; and let me go to the answer that bears upon the importance of NASA, I do believe: Inspiration; vision; 13-year-old kids trying to decide what to do, whether they are going to take advanced math or work hard to get into advanced math, or whatever.

Do you agree with that? And if you do, say so. Starting with you, Norm.

Mr. AUGUSTINE. I was an engineer, before I descended into management, and I strongly agree with you. I contrast my own family. My daughter, her senior year in college, decided she would like to be a lawyer. Today, she is a lawyer and a very good one; I am very proud of her.

My son decided in eighth grade he wanted to preserve the option to be an engineer. He could not decide, his senior year in college or even senior year in high school, to be an engineer. I use eighth grade as my example, you use age 13 or 14, and so we are very close.

Because, if you do not study algebra in eighth grade, you cannot study trigonometry and you cannot study solid geometry. And, because of the hierarchical nature of an engineering education, you have to decide in eighth grade, not that you want to be an engineer or a mathematician, but that you want to preserve the option to do that. Whereas you really do not have to make a decision to preserve the option to be a businessperson or a lawyer, until you are well into college.

So, you need something in eighth grade that makes you want to take advanced algebra. And it is not a lot of fun to take advanced algebra. The average kid will not decide that on their own. I certainly would not have. Somebody has to inspire you; or something has to inspire you.

One of our real problems in this country is with young women who are in eighth grade, very few of whom have the role model that encourages them to study advanced algebra. And as a result, we lose almost one-half the talent in this country, that do not have the opportunity to go into engineering. And we cannot address that in college or high school, we have to address that in eighth grade.

Some parents provide the role model, some friends provide the role model, but the space program—in years past, at least; and it could be, in years future—could be a great inspiration to young people to make that tough decision and to get excited about studying algebra, and so on.

There have been actual studies that have shown a correlation; and I do not want to characterize a causal effect, because I am not capable of proving it—but there is a correlation between the number of people who go into engineering and the size of the NASA budget. When the budget goes up, both go up; and both go down together.

Senator ROCKEFELLER. That is interesting.

Mr. AUGUSTINE. There is a clear correlation. Now, whether it is causal or not, I cannot say one way or the other. But I think you are onto a very, very important point.

Senator ROCKEFELLER. Dan.

Mr. GOLDIN. There was recently something on the wire services, some weeks ago; one of the people I work with told me about it. They did a study, they are always doing studies, and they took a look at children that were interested in math and science, to try and find what were the reasons they were interested in math and science.

Top two reasons: No. 1, Star Trek. No. 2, astronauts and NASA.

And it is very, very interesting, when you think about Star Trek. Star Trek was popular before we started landing astronauts on the Moon; and then, it went out of popularity.

And then, as the space program started dragging out, and the programs became bigger, and the launches less frequent, and the accomplishments and the inspirational portion of the mission less visible—even though we were doing a lot of good work—Star Trek started getting popular again.

And it is still quite popular now. They are now into the next generation. I think they are beyond the next generation. But the fact of the matter is, it is very, very inspirational.

And I want to add onto what Norm said. We have another very major issue in this country. It is not just women, but it is the broad range of Americans that need to be inspired, especially the minority children who are having terrible problems.

And yesterday, I met with a group that was led by a bishop from the A.M.E. church; where we were talking about this very subject, and the need to inspire children.

And many, many educational organizations are now coming to NASA, to have us help them inspire children, starting in kindergarten, and we are developing materials, and we are interacting from kindergarten all the way through the postdoctoral level, because they are coming to us.

We are going to be doubling our educational program for minority children, even though the budget is coming down. We are feeling this tremendous need and pressure, that people want us to be there, to help inspire young children; to give them a vision and something they can grab onto in life. So, I think that the inspiration is important.

And I want to come back to what I talked about before. You tried to get me to say, and I said, "Well, we have got to live with it, and

walk the budget down." And I want to come back to my opening comments, which say: Our Nation has got to decide what we want to invest in.

And if we just go to the space program, and keep taking from the space program, and keep taking to pay for present bills, we have no future. And at some point, we will come to a place where we say, "I am not sure we can have a space program."

Now I think that if, given stability, and if given some reasonable commitment—not measured in decades, but maybe 2 or 3 years would be good, for starters—we can have a solid program.

But I want to say that, if we keep this up—and I am going to reverse what I said before—it is not just a question of canceling one element. If we keep ratcheting the program down, we are going to start having a very, very ill-managed program; and we are not going to be on the road to recovery.

So, I am very, very concerned, and I want to send up a flare right now.

Senator ROCKEFELLER. Thank you, Dan. Dr. Frosch.

Dr. FROSCH. I think this country has always had a tension between visionary things, and trying to be very, very down-to-earth practical.

Our original visionary thing was, in fact, the idea of the country itself, and its politics; and in that history, one had a tension between the vision and the day-to-day details of how one would do trade and economics. And there was always the tension, back and forth.

I think perhaps it is the open frontier idea. Even if the frontier was not everything it was said to be, it was the vision which was pulling the country. I think it is clear that the country thrives when it is doing something visionary; something large; something that people agree is beyond what it is reasonable to try to do, but we are going to try to do it anyway.

Sometimes, the only vision we have, is to win a war; and yet, that serves the vision. We would be much better if we crafted for ourselves some scientific and space visions that we could use to pull ourselves forward.

At the moment, the temper of the time seems to be to reject vision, and deal only with the day-to-day practical. I hope we can find some way to craft ourselves a vision, a space vision, a science vision, that will serve to balance our National psyche a little bit; so that we can deal both with our day-to-day practice, and our—I think—valid need for a national vision.

Senator ROCKEFELLER. Well said, and I agree. Gentlemen, I thank all three of you. You are all important parts of our present, and our future. The hearing is adjourned.

[Whereupon, at 4:45 p.m., the hearing was adjourned.]

APPENDIX

QUESTION ASKED BY SENATOR DANFORTH AND ANSWER THERETO BY MR. AUGUSTINE

Question. Since the release of your 1990 report, Mr. Augustine, and particularly in the last few months, NASA has experienced several major failures with its satellites. I would be very interested in hearing your thoughts on what has changed since the release of your report. Specifically, what recommendations would you make to change the process at NASA? I understand that the Air Force uses an independent launch verification team for its launches, led by an FFRDC. Should NASA be looking at using a similar arrangement? And, if so, are there other areas where this kind of independent review would improve NASA's programs?

Answer. The responsibility for the adequacy of NASA's spacecraft must ultimately reside with the contractors who design, build, test and launch them—and particularly those firms which serve as system prime contractors. NASA of course has an important management oversight role and in this capacity provides an essential check and balance. NASA is quite differently equipped to fulfill this responsibility than the Air Force, with the former having a number of large and highly capable technical laboratories focusing on space pursuits—whereas the latter has very limited space laboratory capability, electing instead to concentrate on program management skills. Because of this difference, the Air Force has for years been provided independent technical support on space matters by the Aerospace Corporation. While NASA certainly has adequate technical capability to fulfill the Aerospace function, it could perhaps be asserted that it enjoys less independence when doing so—particularly given the NASA Centers heavy involvement in the development of some hardware (and Aerospace's almost total abstinence from such activity).

All things considered, it would appear to me that the best solution for NASA is not to create yet another overhead structure (for example, an FFRDC), but instead to increase the involvement of NASA Centers not involved in the project at hand in the review process—thereby furthering independence.

There are, of course, other areas where greater independent review was deemed to be in order by the Advisory Committee on the Future of the U.S. Space Program—most prominently in the area of cost estimating.

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